CESifo WORKING PAPERS

6638
2017
Original Version: August 2017
This Version: June 2020

An Economic Model of Patent Exhaustion

Olena Ivus, Edwin L.-C. Lai, Ted Sichelman

CESifo

Impressum:

CESifo Working Papers
ISSN 2364-1428 (electronic version)
Publisher and distributor: Munich Society for the Promotion of Economic Research - CESifo GmbH
The international platform of Ludwigs-Maximilians University's Center for Economic Studies and the ifo Institute
Poschingerstr. 5, 81679 Munich, Germany
Telephone +49 (0)89 2180-2740, Telefax +49 (0)89 2180-17845, email office@cesifo.de
Editors: Clemens Fuest, Oliver Falck, Jasmin Gröschl
www.cesifo-group.org/wp

An electronic version of the paper may be downloaded
· from the SSRN website: www.SSRN.com
· from the RePEc website: www.RePEc.org
· from the CESifo website: www.CESifo-group.org/wp

CESifo *Working Paper No. 6638*
Category 11: Industrial Organisation

An Economic Model of Patent Exhaustion

Abstract

The doctrine of patent exhaustion implies that the authorized sale of patented goods "exhausts" the patent rights in the goods sold and precludes additional license fees from downstream buyers. Courts have considered absolute exhaustion, in which the patent owner forfeits all rights upon an authorized sale, and presumptive exhaustion, in which the patent owner may opt-out of exhaustion via contract. This paper offers the first economic model of domestic patent exhaustion that incorporates transaction costs in licensing downstream buyers and considers how the shift from absolute to presumptive exhaustion affects social welfare. We show that when transaction costs are high, the patent owner has no incentive to individually license downstream users, and absolute and presumptive exhaustion regimes are equivalent. But when transaction costs are at the intermediate level, the patent owner engages in mixed licensing, individually licensing high-valuation buyers and uniformly licensing low-valuation buyers. Presumptive exhaustion is socially optimal when social benefits from buyer-specific pricing outweigh social costs from transaction cost frictions in individualized licensing, which requires sufficiently low transaction costs.

JEL-Codes: F100, O340.

Keywords: intellectual property, patent exhaustion, first sale doctrine, patent licensing.

*Olena Ivus**
Smith School of Business
Queen's University
143 Union Street
Canada – Kingston, ON K7L 3N6
olena.ivus@queensu.ca

Edwin L.-C. Lai
Department of Economics
Hong Kong University of Science and Technology, Clear Water Bay
Kowloon / Hong Kong
elai@ust.hk, Edwin.l.lai@gmail.com

Ted Sichelman
University of San Diego
School of Law
5998 Alcalá Park
USA - San Diego, CA 92110-2492
tsichelman@sandiego.edu

*corresponding author

We thank Jonathan Barnett, Dan Burk, John Duffy, Jay Kesan, Mark Lemley, Robert Merges, Adam Mossoff, Zorina Khan, Michael Risch, Mark Schultz, and participants at the 2016 Patent Law Scholars Roundtable at the University of San Diego School of Law, the 2017 Searle Roundtable on Patents and Technology Standards at the Northwestern University, the 2017 Intellectual Property Scholars Conference at Cardozo School of Law, the 2017 HKUST Workshop on Law and Economics, and the Thomas Edison Innovation Fellowship Meeting in Austin, Texas, for helpful comments and discussions on earlier drafts. We especially thank Parth Sagdeo for his invaluable research assistance. This paper is funded in part by a grant from the Center for Protection for Intellectual Property, Antonin Scalia Law School, George Mason University, but the contents are solely the responsibility of the authors.

1 Introduction

Within the United States, the judge-made doctrine of "patent exhaustion" (sometimes termed the "first-sale" doctrine) implies that authorized sales of patented goods—e.g., by a manufacturer directly authorized by the patent owner—"exhausts" any rights of the upstream patent owner to seek payment from downstream buyers. However, in some instances, upstream patent owners attempt to contractually restrict downstream buyers—for example, prohibiting resale of the good—in order to preserve their right to collect additional license fees. Whether and under what circumstances such downstream contractual restrictions can overcome the doctrine of patent exhaustion has been the subject of many conflicting, and often vague, judicial decisions over the past century. The legal literature has qualitatively examined the arguments for and against absolute patent exhaustion, but the qualitative literature provides no clear framework to resolve the issue of whether absolute exhaustion increases or decreases overall welfare. In the economics literature, several scholars have examined the exhaustion doctrine in the international context but surprisingly, very few have advanced a formal model of domestic patent exhaustion.

This paper offers the first economic model of domestic patent exhaustion that incorporates transaction costs in buyer-specific patent licensing, and also allows for two types of licensing of buyers by the patent owner—*individualized licensing* (buyer-specific) directly from the patent owner and *uniform licensing* via the manufacturer. In this context, we examine how a shift in domestic patent policy from absolute to presumptive exhaustion (which presumes exhaustion but allows the patent owner to opt-out via contract) affects social welfare.[1]

Our model is motivated by a transactional structure common in the high-technology industries addressed by the U.S. Supreme Court in the patent exhaustion case of *Quanta Computer, Inc. v. LG Electronics, Inc.* (2008), which we discuss further below. In our stylized model of this transactional structure, there exists one patented component of a complex product. In order for a manufacturer to produce the good, it must enter into a license with the patent owner. We assume the patent provides market power to the patent owner, which in turn selects one of many competitive manufacturers to produce and sell the good. The patent owner thus licenses the component to only one manufacturer, making the manufacturer a monopolist in the market for the good.[2] Buyers differ in their willingness to pay for the good. Note that "buyers" are often themselves downstream manufacturers of their own complex product.[3] The price a buyer is charged

[1]Although we refer to patents here, our model is also applicable to exhaustion in the copyright context.

[2]The patent owner will be able to extract all rents from the manufacturer when the patent owner has a monopoly position via the patent and there is a competitive manufacturing market.

[3]In the case of a downstream computer manufacturer (e.g., Dell) purchasing patented components from an upstream manufacturer of computer parts (e.g., Intel), our model would treat Dell as the "buyer" and Intel as the

depends on the regime of patent exhaustion.

Under absolute exhaustion (Regime AE), when the manufacturer sells the good to the buyer, the patent owner loses all rights to proceed against the buyer for patent infringement. Under presumptive exhaustion (Regime PE), the patent owner may opt out of exhaustion by imposing contractual restrictions on the buyer, in which case the buyer must enter into a license with the patent owner or risk patent infringement. We allow for two types of licensing of buyers in Regime PE—individualized and uniform—and assume that a license from the patent owner (of either type) provides the buyer with a right to use the good but not to resell it.[4] Precluding resale in Regime PE implies arbitrage will not occur, and the patent owner and manufacturer can price discriminate between buyers in the first degree. Regime AE, by contrast, prevents contractual restrictions on buyers and as such, allows resale; consequently, pricing is uniform.[5] Importantly, we allow for a positive transaction cost in individualized licensing, which increases the unit cost of producing the final good for those who are licensed individually. This transaction cost is critical in determining the social welfare implications of patent exhaustion. It includes the time and effort involved in negotiating license fees and executing separate licensing agreements with individual buyers.[6]

The size of the transaction cost affects the patent owner's optimal licensing scheme in Regime PE. When the transaction cost is positive but not excessively high, the patent owner will engage in *mixed licensing*, individually licensing high-valuation buyers and uniformly licensing low-valuation buyers. Mixed licensing features a tradeoff between social benefits in the form of price discrimination and social costs generated by transaction cost frictions. Two insights, not recognized in the previous literature, arise. First, at intermediate levels of transaction costs, the patent owner does not fully internalize the social costs of licensing in its single-minded, private goal of rent maximization. Thus, when allowed to do so in Regime PE, the patent owner will succumb to the classic economic problem of rent dissipation, willing to burn up essentially all of a buyer's individual surplus in order to gain a penny of producer surplus. Secondly, at sufficiently low levels of transaction costs, the patent owner's private incentive to maximize rents may lead to net social gains. Specifically, the ability of the patent owner to price discriminate implies that more

"manufacturer."

[4]These assumptions are consistent with the real-world practice of downstream patent licensing in a regime of presumptive exhaustion. Legally, there is no need to directly license buyers to impose downstream restrictions, and the cost of adding such restrictions in a license (of either type) is negligible.

[5]We discuss resale in more detail in Section 6. Also, we abstract away from the possibility that the patent owner enforces its licensing restrictions through a contract suit, which is not necessarily barred by absolute exhaustion, rather than a patent suit. As we explain in footnote 11, contractual suits are generally not as effective in these situations. To the extent contractual actions allow patent owners to "imperfectly" enforce downstream restrictions, our results would not change qualitatively, but the welfare effects of the exhaustion regimes would be less pronounced.

[6]We assume all parties know the buyer's type. We discuss information asymmetry in assessing the buyer's demand in Section 6.

buyers may gain access to the patented good than in Regime AE. In other words, while Regime PE burns up surplus in the transaction costs when the patent owner engages in individualized licensing, these costs may be worth the candle if enough additional producer surplus is generated and enough additional buyers gain access to the good. Our model shows that when transaction cost frictions are sufficiently low, presumptive exhaustion is optimal.

We briefly discuss extensions to our model in Section 6 and more formally discuss how to relax some of the assumptions in a supplementary online appendix.[7] In particular, we note that dynamic gains in promoting *ex ante* investment in product quality may outweigh any loss of static efficiency in Regime PE when the transaction cost is high. Regime PE is also more likely to dominate (in static terms) when licensing is via heterogeneous intermediaries (e.g., wholesalers, resellers), with each intermediary negotiating the license fees on behalf of a large number of buyers. But when there are information frictions, which act as an increase in transaction costs—such as information asymmetry in assessing the buyer's demand and search costs—Regime AE is more likely to dominate. Our results also hold qualitatively when we allow for a positive transaction cost in manufacturer licensing or substitutes for the patented component, consider goods comprising multiple patented components, or allow buyers to resell used patented products on a secondary market.

In the economics literature, Maskus and Chen (2004), Valletti (2006), Valletti and Szymanski (2006), Grossman and Lai (2008), and Saggi (2013, 2014) are valuable contributions that offer models of patent exhaustion. But these models are limited to parallel trade among countries and draw a distinction between the regimes of national and international exhaustion, under both of which the exhaustion is absolute. This is in contrast to recent legal decisions and case comments, which focused on the distinction between absolute and presumptive domestic exhaustion. Furthermore, the effects of international exhaustion cannot be easily adapted to the domestic context.[8]

Only one paper, Layne-Farrar et al. (2014), formally models domestic patent exhaustion. In that model, a patent owner can grant a license to an upstream manufacturer and, if absolute patent exhaustion does not apply, also to a downstream manufacturer. The model focuses on royalty allocation among the three parties but abstracts away from the issue of transaction costs in downstream licensing, which is a critical feature of our model.

Although the previous literature recognized that absolute exhaustion and presumptive exhaustion are equivalent when transaction costs are so prohibitive that there is no incentive for the patent owner to engage in downstream licensing, it did not describe the shift from prohibitive to intermediate to low levels of transaction costs (e.g., Layne-Farrar et al., 2014). Rather, some scholars

[7] The supplementary online appendix can be found at `https://ssrn.com/abstract=3634038`.

[8] Brown and Norman (2003) discusses domestic exhaustion, but merely in the context of international trade.

focused on how exhaustion solves the problem of rent dissipation burning up transaction costs (e.g., Mulligan, 2013), while others criticized exhaustion for preventing socially beneficial price discrimination (e.g., Kieff, 2018). No previous scholar has provided the means of determining, as our model does, when one of these competing interests dominates the other.

This paper's contribution to the literature is threefold. First is the modeling contribution. We offer the first economic model of domestic patent exhaustion that incorporates transaction costs in downstream licensing, an issue that has caused ongoing, unresolved debate in the legal literature. Our framework is rigorous yet simple and can be easily extended to study other aspects of patent exhaustion. Second, we identify the reasons why transaction costs place a wedge between private and social welfare. The third major contribution is our detailed formal study of domestic exhaustion, particularly the distinction between absolute and presumptive exhaustion. This distinction has been the focus of recent legal decisions and qualitative scholarship, but—with the exception of Layne-Farrar et al. (2014)—has not been presented in the economic literature. We seek to bring the two strands of literature together to provide a formal model, with a variety of extensions.

The rest of the paper proceeds as follows. Section 2 briefly provides a background on the doctrine of exhaustion. Section 3 sets up our model and outlines the patent exhaustion regimes. Section 4 solves for the equilibrium prices and license fees under each of the regimes, and Section 5 examines social welfare. Section 6 discusses extensions to our model, and Section 7 discusses the implications for policy. Section 8 concludes.

2 Background on the Doctrine of Exhaustion

So far in the U.S., the exhaustion doctrine's application and scope has been determined by case law. Despite many Supreme Court and lower court decisions, as of the mid-2000s, legal academics and practitioners were quite uncertain as to whether absolute or presumptive exhaustion should apply, with many seemingly conflicting opinions in the lower courts. To resolve this critical issue, the Supreme Court granted certiorari in *Quanta Computer, Inc. v. LG Electronics, Inc.* (2008). Here, the U.S. Supreme Court examined the exhaustion doctrine in the context of computer microprocessors and memory. LG Electronics owned patents covering specific aspects of computer memory. LG licensed Intel, a manufacturer of computer chips, but in its license agreement to Intel, expressly reserved a license to any third party that sought to combine Intel products with its own or other third party products. For instance, if the license agreement were interpreted at face value, it would prevent Dell from combining its or other third party components with Intel's chips in order to manufacture a computer for sale to end-consumers, absent a separate, individualized license from LG, the patent owner, to Dell.

Given the prevalence of the form of transaction structure in the *Quanta v. LG*, we base our economic model on the facts in this case. As in our model, there is a single owner with market power (LG), which licenses manufacturers such as Intel.[9] The manufacturer, Intel, sells patented components to buyers, which are typically downstream manufacturers, such as Dell, Lenovo, and Asus, for use in a complex product, such as a computer. In Regime AE, assuming Intel's sale is authorized, Dell, Lenovo, and Asus can use Intel's chips—including reselling them to each other—without having to fear a patent suit from LG. In other words, absolute exhaustion trumps whatever ostensible restrictions were imposed on the use of the chips through the provision in LG's license to Intel precluding downstream third parties from combining Intel chips with third-party components. Knowing that buyers can resell the chips to one another—which for chips is relatively costless compared to the value of the chip—Intel will set a uniform price for the chip that reflects the maximum producer surplus it can earn from the buyers. LG will then extract some or all of that surplus through a licensing fee charged to Intel, based on the level of its market power enabled by its patents.

In contrast, in Regime PE, LG's licensing restrictions, if properly drafted, would preclude Dell, Lenovo, and Asus from using Intel's chips to manufacture computers unless each of these manufacturers entered into a separate license with LG. Because LG could impose restrictions in such a license on reselling the Intel chips to other manufacturers, LG could price discriminate among the buyers by charging different licensing rates based on each buyer's willingness to pay, as long as the transaction costs of such individualized licensing were less than the gain to LG. Indeed, given the ability to price discriminate in Regime PE, LG could reduce its license fee to Intel, which might cause Intel to reduce its chip prices in order to increase overall sales by identifying new buyers (e.g., Acer) that were not able to afford the chips in Regime AE.

Yet, the Supreme Court never decided whether absolute or presumptive exhaustion applies in the *Quanta* case, because it essentially found that LG did not properly draft its licensing restrictions, mooting the issue. In other words, because LG's licensing restrictions were not properly drafted, Intel's sales were both authorized and without restriction as to its customers combining Intel chips with their own or third-party components. Although the court reaffirmed that exhaustion applies to domestic sales and held that patent exhaustion is triggered by, among other things, an authorized sale of a component that "substantially embodies" the patent in question—even if it does not completely practice the patent—the Supreme Court's decision did little to dispel the confu-

[9] For simplicity, as noted earlier, we assume the patent owner has full monopoly power and there is a single manufacturer, but we examine the implications of relaxing these assumptions in Section 6.

sion about what constitutes "authorization" or whether a patent owner can impose contractual restrictions on downstream buyers to limit patent exhaustion.

The Supreme Court once again considered exhaustion in *Bowman v. Monsanto* (2013), with the unusual facts of whether the sale of a patented soybean seed to a farmer exhausts the right to essentially identical seeds generated by the soybean plant itself. Specifically, Bowman purchased the patented soybean seeds, subject to the contractual restriction that he not save and use any of the seeds produced by the soybean plant grown from the patented seeds. Rather than deciding whether absolute or presumptive exhaustion applies in this situation, the Court simply reiterated the longstanding rule that "the exhaustion doctrine does not extend to the right to 'make' a new product." Because Bowman was essentially making a new product from the original seeds, exhaustion did not apply, and Monsanto's licensing restrictions were effective.

Finally, in *Lexmark Int'l, Inc. v. Impression Products, Inc.* (2017), the Supreme Court decided that absolute exhaustion applies to all authorized sales or products covered by U.S. patents. Lexmark sold its printer cartridges under two pricing options: a "regular cartridge" at "list price" and a "return program cartridge" at a discount. The sale of the return program cartridge was accompanied by post-sale contractual restrictions that the cartridge was not to be reused or resold, whereas the regular cartridges could be freely reused or resold. In violation of these restrictions, Impression acquired used return program cartridges from Lexmark's customers within and outside the U.S. and then altered and resold the cartridges in the U.S., undermining Lexmark's ability to implement differential pricing.[10]

Two key questions were presented in *Lexmark* regarding the scope of the patent exhaustion doctrine. First, whether the doctrine of absolute exhaustion applies to end Lexmark's patent rights upon its authorized sale of the cartridges to its customers, or whether presumptive exhaustion applies so that Lexmark's contractual restrictions on the cartridge's reuse and resale override the exhaustion doctrine and may be effectively enforced through a patent infringement lawsuit. Second, whether Lexmark exhausted its patent rights by selling its cartridges *outside* of the U.S., so that Impression can import the cartridges into the U.S. and resell without being liable for patent infringement (so-called "international exhaustion").

[10]The transaction structure in *Lexmark* is relatively uncommon, because most patented products cannot typically be rebuilt at a low cost and essentially sold again as new. Rather, most patented products are either immediately consumed and "wasted" to zero value (e.g., pharmaceutical drugs) or the value is diminished very quickly and cannot be easily restored (e.g., computer chips). Although there is often a secondary, "used" market for the second class of patented goods by end-consumers, typically these resales do not have a large impact on the prices and royalties relating to the goods when sold anew. For these reasons, we ignore the *Lexmark*-style transaction and resale markets in this paper, though we extend our model to more general secondary, resale markets in the online appendix.

The economic importance of these legal issues is underscored by the very large number of major companies that filed over forty amicus briefs at the Supreme Court. Intel, LG Electronics, Samsung, eBay, Amazon and other firms that rely on numerous patent-protected inputs to the products they produce or sell opposed presumptive exhaustion. They argued that allowing upstream patent owners to impose downstream contractual restrictions would require a downstream firm to "trace the patent rights of every component it purchases and then negotiate appropriate license arrangements with the component manufacturer (as well as any subcomponent manufacturer)." Such tracing and negotiation would in their view engender substantial transaction costs, diminishing the efficient distribution of patented goods. On the other side, the Pharmaceutical Research and Manufacturers of America (PhRMA), the Biotechnology Industry Organization (BIO), and the Intellectual Property Owners Association (IPO) opposed a broader scope of patent exhaustion. These organizations represent firms and individuals that depend substantially on patent rents and so not surprisingly, they argued that patent exhaustion should remain limited so as to allow firms to engage in domestic and geographical price discrimination.

In May 2017, the Supreme Court ruled in Impression's favor, holding that (1) a patentee's decision to sell a product exhausts all of its patent rights in that item, regardless of any restrictions the patentee purports to impose; and (2) an authorized sale outside the U.S., just as one within the U.S., exhausts all rights under the Patent Act. With this decision, the Supreme Court overturned the Federal Circuit's ruling that upstream patent owners may opt out of patent exhaustion via contractual restrictions, and that patent rights are not exhausted by an authorized sale abroad (even where no reservation of rights accompanies the sale). This decision also contravened the U.S. government's position that a foreign sale authorized by the U.S. patentee should exhaust U.S. patent rights by default unless the patentee expressly reserved those rights.[11]

A common justification for exhaustion found in judicial decisions and legal scholarship (e.g.,

[11] The Supreme Court's decision left open the possibility of contractual actions to enforce downstream restrictions. If a licensee has exceeded the limitations in a license agreement directly executed between the patent owner and the licensee, the patent owner may be able to assert a contract claim. Nonetheless, patent owners tend to favor patent claims. First, patent claims offer a wider array and scope of remedies, particularly injunctive relief; while contract claims usually afford no consequential or punitive damages. Also, patent cases are tried in federal courts with a relatively uniform body of nationwide law, which is often preferred to state courts, which may vary widely in applicable law. Finally, to enforce downstream restrictions in contract, "privity"—that is, some direct contractual relationship between the parties—is required. In *Lexmark*, for example, Lexmark (the patent owner) could not assert a contractual claim against Impression (the alleged infringer), because Impression purchased the cartridges from the Lexmark's customers rather than Lexmark itself. Although a patent owner can attempt to impose a "nested" set of downstream contracts so as to ensure privity with downstream parties, achieving as much is not a certainty and it raises transaction costs. This is especially so if the contractual "intermediaries" between the patent owner and downstream resellers are ordinary customers, which patent owners are typically averse to sue because of negative repercussions in the marketplace. So it is not surprising that patent owners vigorously oppose any exhaustion of the patent rights underlying such claims, or that the matter of exhaustion is of such great importance to downstream resellers and users.

Skladony, 2007) is that once the patent owner is paid by a licensee for the use of a patented good, it has no right to further payment. As the U.S. Supreme Court stated in *Bloomer v. Millinger* (1863), patent owners "are entitled to but one royalty for a patented machine." However, such contentions are more conclusory than evincible. There is no *a priori* reason to assume a single license to an intermediate manufacturer, reseller, or purchaser is sufficient to induce optimal investment. Perhaps, as the Federal Circuit stated in *Mallinckrodt, Inc. v. Medipart, Inc.* (1992), the patent owner charges less than the full value available under the proper scope of the patent to each licensee, so that in effect there is no double counting. Another justification for exhaustion—and one heavily relied upon by the U.S. Supreme Court in *Lexmark' Int'l, Inc. v. Impression Products, Inc.* (2017)—is the general aversion to restraints on alienation; namely, that it is economically efficient to allow the sale and transfer of goods (e.g., Carrier, 2004). Katz (2016), for instance, explains that exhaustion can eliminate supernormal pricing for patented goods and thereby reduce deadweight loss. Perzanowski and Schultz (2011) argues that exhaustion can reduce situations of buyer "lock in" and diminish switching costs, by allowing users to more easily switch to competing technologies. Exhaustion can also reduce the rent dissipation that may occur when the transaction costs of licensing are high (Mulligan, 2016) and prevent anticompetitive practices (e.g., tying, resale price maintenance, and exclusive dealing), which can be imposed on downstream licensees via contract and may not survive antitrust scrutiny (Hovenkamp, 2016).[12] A counterargument is that absolute exhaustion can reduce overall efficiency by precluding the typically efficiency-enhancing effects of freedom of contract, particularly when the contractual restraints are vertical in nature (Kieff, 2008; Hovenkamp, 2011; Katz, 2016).[13] In this regard, presumptive exhaustion allows for price discrimination, which may reduce deadweight loss and increase incentives to innovate. Also, while absolute exhaustion could alleviate the restraints on alienation concerns, other instruments (such as the patent misuse doctrine and the antitrust laws) are more suitable for the purpose.[14]

Against that background, it is clear that U.S. patent exhaustion policy is a serious and contentious issue, which is of fundamental importance in numerous industries (e.g., pharmaceutical drugs, semiconductors, software) and carries with it significant consequences for trade and welfare, both domestic and abroad. Yet the actual policy implications of patent exhaustion are far from clear.

[12]Indeed, many of the judicial opinions addressing patent exhaustion arise in the context of downstream tying restrictions. In *Henry v. A.B. Dick Co.* (1912), the U.S. Supreme Court upheld downstream licensing restrictions that required purchasers to use the patentee-manufacturer's patented mimeograph machine with its unpatented supplies. Just five years later, in *Motion Picture Patents Co. v. Universal Film Mfg. Co.* (1917), the Court overruled its holding in *A.B. Dick Co.* by finding that a similar downstream restriction was invalid.

[13]Unlike horizontal restraints, vertical restraints do not constrain direct competitors (Meurer, 2003).

[14]We abstract away from these anticompetitive issues here and address exhaustion doctrine's most basic concern: the ability of the downstream buyer to use or resell the patented good in the absence of a separate license from the patent owner.

3 Model Set-up

Consider a closed economy in a country populated with L buyers. Assume there exists a good y that has quality h.

Buyers have vertical preferences and differ in their type ϕ, which determines their willingness to pay for goods of a certain quality.[15] A buyer of a type $\phi > p/h$ purchases one unit of good y of quality h at a price p and earns utility (i.e., individual consumer surplus) of $U(\phi) = h\phi - p$. A buyer of a type $\phi < p/h$ does not purchase good y and earns utility of zero. We assume that ϕ is uniformly distributed over the interval $[0, 1]$. Given uniform price p, the quantity demanded q is linear and is given by the number of buyers who purchase good y:

$$q = L \int_{p/h}^{1} d\phi = L\left(1 - \frac{p}{h}\right). \tag{1}$$

The production of good y requires one differentiated component, x, which is patented by a third-party patent owner. The patent provides market power to the patent owner, as there are no substitutes for x.[16] Besides the component x, labor and materials are the only other inputs into the production of y. The per-unit cost of labor and materials is constant and equal to γ. The fixed cost of production of y is zero.

We assume that a potential manufacturer of y will obtain a license from the patent owner to make and sell component x as part of good y. This is because a manufacturer can accurately estimate the probability of losing a patent infringement suit and given litigation costs, it is less costly to negotiate a license *ex ante* rather than risk being sued for patent infringement. The manufacturer will pay a license fee of λ_m per unit of x plus a lump sum fee of $\bar{\lambda}$ to the patent owner.

Ex ante, there is a large number of identical potential manufacturers of good y competing for the use of x. This competition among potential manufactures *ex ante* allows the patent owner to adjust $\bar{\lambda}$ so as to recover all profit from the licensed manufacturer(s) *ex post*, making the manufacturer(s) break even. The patent owner maximizes its rents from license fees by licensing x to only one manufacturer, thus making this manufacturer a monopolist in the market for y that it sells.[17]

We consider two legal regimes regarding patent exhaustion:

[15] The model is a vertically differentiated model as in Shaked and Sutton (1982). It is also adopted in Valletti (2006), Valletti and Szymanski (2006), Saggi (2013), and Ivus and Lai (2018).

[16] We discuss how allowing for unpatented substitutes for x affects our results in Section 6 and present a more formal analysis in Section A.4 in the online appendix.

[17] We assume the manufacturer has the capacity and distribution network to satisfy the total demand.

***Regime AE - Absolute Exhaustion*:** When the manufacturer sells the good to the buyer, regardless of the patent owner's desires, the patent owner loses all rights to proceed against the buyer for patent infringement.

***Regime PE - Presumptive Exhaustion*:** The patent owner loses all rights to proceed against the buyer for patent infringement unless the patent owner imposes downstream contractual restrictions on the buyer. If the patent owner imposes such restrictions, the buyer must enter into a license with the patent owner or risk patent infringement.

Regime AE prevents contractual restrictions on buyers and as such, allows resale. The patent owner licenses the manufacturer to give it the right to manufacture and sell the good. We assume that the patent owner's and the manufacturer's incentive to price discriminate is eroded by a perfect and costless arbitrage.[18] Consequently, the manufacturer will set a uniform price for the patented product.

In Regime PE, the patent owner may opt out of exhaustion (which is the default rule) by imposing downstream contractual restrictions. If the patent owner imposes a downstream contractual restriction that effectively restricts the use or sale of the patented component by a buyer, then in order to avoid a charge of patent infringement, the buyer needs to separately enter into a license with the patent owner. The patent owner can directly license the buyer or use an agent to do so (such as the manufacturer), but either way, the terms and price of the license can be customized to individual buyer. For simplicity, we assume that the individualized licensing (when profitable) is direct, i.e., between the patent owner and the buyer, without going through the manufacturer. Assuming the cost of opting out is zero, the patent owner has a choice between *uniform licensing* (which involves sublicensing all buyers via the manufacturer under a uniform manufacturer license), *individualized licensing* (which is buyer-specific, i.e., perfect price discrimination), or *mixed licensing* (which involves individualized licensing of some buyers and uniform licensing of others). Here, we assume that a license from the patent owner or the sublicense from the manufacturer provides the buyer with a right to use the good but not to resell it[19] and so, the patent owner and manufacturer can exercise first degree price discrimination among the buyers. However, there is a positive transaction cost in individualized licensing, t, which includes the time and effort involved in negotiating license fees and executing licensing agreements with individual buyers of different type. The transaction cost increases the unit cost of y to $\gamma + t$.[20] We assume that licensing via the

[18] In component-manufacturer markets, where concerns of patent licensing and exhaustion are most applicable, resale can occur at very low cost.

[19] We assume that it is costless for the manufacturer to insert a sublicensing clause into its form agreement so as to provide downstream rights to buyers; and that both the manufacturer and buyers forgo negotiation over the sublicense clause.

[20] The patent owner's cost in negotiating and executing a single licensing deal with the manufacturer is negligible

manufacturer does not involve transaction cost. Thus, under uniform licensing, the patent owner avoids the transaction cost by licensing via the manufacturer. However, it also fails to extract all consumer surplus.

Another possibility is a regime of *Absolute No Exhaustion*, in which regardless of the patent owner's desires, buyers, upon purchase of the good from the manufacturer, receive no license to make, use, or sell the patented good, and must enter into a license with the patent owner or risk patent infringement. This regime is effectively equivalent to presumptive exhaustion if the transaction cost is zero. More importantly, no court has ever adopted it. As such, we ignore it.

4 Equilibrium

The model has three stages. In Stage I, the government sets the exhaustion regime. In Stage II, depending on the exhaustion regime, the patent owner may implement a licensing scheme. In Regime PE, the patent owner chooses between uniform, individualized, and mixed licensing. Under uniform licensing, the patent owner will set the manufacturer license fee of λ_m per unit of x and a lump-sum fee of $\bar{\lambda}$, and will license all buyers via the manufacturer. Under individualized licensing, the patent owner will maximize the overall rent from licensing by setting the manufacturer license fees to zero ($\lambda_m = \bar{\lambda} = 0$), in order to have the most flexibility in setting the buyer-specific license fees λ_ϕ paid directly by buyers, and will then set λ_ϕ to extract all individual consumer surplus. Under mixed licensing, the patent owner will choose the marginal type ϕ^* and will individually license high-valuation buyers with type $\phi \in [\phi^*, 1]$ and uniformly license low-valuation buyers with type $\phi \in [p/h, \phi^*)$ via the manufacturer (since their individual licensing is too costly relative to their willingness to pay for the final good).[21] High-valuation buyers will pay the buyer-specific license fee λ_ϕ on top of the (uniform) manufacturer's price, and low-valuation buyers will be licensed via the manufacturer and will pay the manufacturer's price. In Regime AE, the patent owner chooses the manufacturer license fees but does not engage in individualized licensing. In Stage III, the manufacturer sets the price p on the good to be sold to buyers, taking into account the license fees. The model is solved using backward induction.

In the rest of this section, we consider Regime PE. When exhaustion is presumptive, the patent owner's choice of a licensing scheme depends on the size of the transaction cost in individualized

in comparison, and ignored for simplicity.

[21] Such mixed-licensing is common in many industries, as it allows the patent owner to extract some value immediately downstream, and then further value from high-valuation users for which transaction costs are relatively unimportant.

licensing, t, and to show this, we examine the following three cases: zero transaction costs in Section 4.1; intermediate transaction costs in Section 4.2; and prohibitive transaction costs in Section 4.3. The outcome in Regime AE is equivalent to that in Regime PE with prohibitive transaction costs, since the patent owner will not engage in individualized licensing in this case.

4.1 Regime PE with zero transaction costs

When $t = 0$, the patent owner will engage in individualized licensing. This follows since, as we show below, the patent owner's overall rent from individualized licensing, which is given by equation (6), exceeds that from uniform licensing, which is given by equation (5).

Uniform licensing

Consider first uniform licensing. In Stage III, the manufacturer sets a price p to maximize its profit Π (exclusive of $\bar{\lambda}$), which depends on λ_m and is given by:

$$\Pi = (p - \lambda_m - \gamma)q = (p - \lambda_m - \gamma)L\left(1 - \frac{p}{h}\right), \tag{2}$$

The profit maximizing price and from equation (1), the aggregate quantity demanded at this price are as follows:

$$p = \frac{1}{2}(h + \lambda_m + \gamma) \qquad \text{and} \qquad q = \frac{L}{2h}(h - \lambda_m - \gamma). \tag{3}$$

In Stage II, the patent owner chooses λ_m and sets $\bar{\lambda} = \Pi$ to extract all the rents from the manufacturer. The patent owner's overall rent is $R_m = \lambda_m q + \Pi$. Using equations (2)-(3), we obtain:

$$R_m = \frac{L}{4h}(h + \lambda_m - \gamma)(h - \lambda_m - \gamma). \tag{4}$$

Differentiating R_m with respect to λ_m and setting the derivative to zero, we find the optimal per-unit license fee: $\lambda_m = 0$.[22] The zero per-unit license fee allows the patent owner to avoid double marginalization and in doing so, maximize the manufacturer's profit, which is then extracted via a lump-sum license fee. A positive λ_m, by contrast, would reduce the aggregate quantity below the profit maximizing level.

The patent owner's overall rent from uniform licensing is thus as follows:

$$R_m = \frac{L}{4h}(h - \gamma)^2. \tag{5}$$

[22]The second order condition for maximization is satisfied as $\partial^2 R_m / \partial \lambda_m^2 = -1 < 0$.

In Stage III, the manufacturer sets $p = (h + \gamma)/2$, which follows from equation (3) when $\lambda_m = 0$.

Individualized licensing

Consider now individualized licensing when $t = 0$. In Stage III, the manufacturer is left with zero residual consumer surplus to be extracted and so, will set the price p equal to the marginal cost γ. In Stage II, the patent owner will set λ_ϕ equal to the reservation price $p_\phi = h\phi$ net of the price charged by the manufacturer to buyers, $p = \gamma$. The marginal buyer type that maximizes the patent owner's rent from individualized licensing will be $\phi^* = \gamma/h$. Buyers with type $\phi \geq \gamma/h$, who are willing to pay at least γ, will be charged the price of $p_\phi = h\phi$ or equivalently, the price of γ paid to the manufacturer plus the licensing fee of $\lambda_\phi = h\phi - \gamma$ paid to the patent owner. The patent owner's overall rent from individualized licensing will be given by:

$$R_c = L \int_{\gamma/h}^{1} (h\phi - \gamma) d\phi = \frac{L}{2h}(h - \gamma)^2. \tag{6}$$

4.2 Regime PE with intermediate transaction costs

Suppose the transaction cost is positive. In this case, the patent owner can still capture the entire total surplus with individualized licensing but must internalize the transaction cost. Alternatively, if the patent owner engages in uniform licensing via the manufacturer, the patent owner will avoid the transaction cost but will fail to capture the entire total surplus via the manufacturer, since the manufacturer will set a single monopoly price. Both the patent owner and the manufacturer can price discriminate between buyers in the first degree at the transaction cost of t, but the two parties' incentive to do so is fully aligned (since the patent owner extracts all the rents from the manufacturer with a lump-sum fee). Hence, if individualized licensing of buyers is not optimal for the patent owner, it is not optimal for the manufacturer either, and so the manufacturer will choose to serve the buyers under a single monopoly price.

Mixed licensing

When t is positive but low enough to satisfy $t < (h-\gamma)/2$, the marginal buyer type that maximizes the patent owner's overall rent from licensing will be $\phi^* < 1$, and the patent owner will engage in mixed licensing, individually licensing high-valuation buyers with type $\phi \in [\phi^*, 1]$ and uniformly licensing low-valuation buyers with type $\phi \in [p/h, \phi^*)$. In Stage III, the manufacturer will be left with zero residual consumer surplus to be extracted from high-valuation buyers and so, its price for high-valuation buyers will equal to the unit cost of a good: $p^H = \gamma + t$. The price for low-valuation buyers, denoted by p^L, will be set to maximize the manufacturer's profit Π, which is given by:

$$\Pi = (p^L - \lambda_m - \gamma)q^L = (p^L - \lambda_m - \gamma)L\left(\phi^* - \frac{p^L}{h}\right), \tag{7}$$

where q^L is the number of uniformly licensed low-valuation buyers, given by:

$$q^L = L\int_{p^L/h}^{\phi^*} d\phi = L\left(\phi^* - \frac{p^L}{h}\right). \tag{8}$$

The profit maximizing price and the aggregate quantity demanded at this price are as follows:

$$p^L = \frac{1}{2}(h\phi^* + \lambda_m + \gamma) \quad \text{and} \quad q^L = \frac{L}{2h}(h\phi^* - \lambda_m - \gamma). \tag{9}$$

In Stage II, the patent owner will set the buyer-specific license fee of $\lambda_\phi = h\phi - \gamma - t$ for high-valuation buyers and will earn the following overall rent from individualized licensing:

$$R_c = L\int_{\phi^*}^{1}(h\phi - \gamma - t)d\phi = \frac{L}{2}(1-\phi^*)[h(1+\phi^*) - 2(\gamma + t)]. \tag{10}$$

The patent owner will also set the manufacturer license fee of λ_m per unit of x and a lump-sum fee of $\bar{\lambda} = \Pi$ and will earn the following rent from uniform licensing:

$$R_m = \lambda_m q + \Pi = \frac{L}{4h}\left[(h\phi^* - \gamma)^2 - \lambda_m^2\right] = \frac{L}{4h}(h\phi^* - \gamma)^2, \tag{11}$$

which follows since the optimal per-unit manufacturer license fee is $\lambda_m = 0$.

The patent owner's total rent from mixed licensing will be equal to $R_T \equiv R_m + R_c$. Differentiating R_T with respect to ϕ^* and setting the derivative to zero, we find the marginal buyer type:[23]

$$\phi^* = \frac{1}{h}(\gamma + 2t). \tag{12}$$

It is true that $\phi^* < 1$ when the transaction cost satisfies $t < (h - \gamma)/2$.

When $\phi^* = (\gamma + 2t)/h$, it follows from (9) that the price for low-valuation buyers is equal to $p^L = \gamma + t$, which is the same as the price for high-valuation buyers, $p^H = \gamma + t$. Hence in Stage III, the manufacturer will set a price of $p = \gamma + t$ for all buyers. High-valuation buyers with type $\phi \in [(\gamma + 2t)/h, 1]$ will be licensed directly and pay the price of $p_\phi = h\phi$ or equivalently, the price

[23] $dR_T/d\phi^* = -hL/2 < 0$. Therefore, the second order condition is satisfied as well.

of $p = \gamma + t$ paid to the manufacturer plus the license fee of $\lambda_\phi = h\phi - \gamma - t$ paid to the patent owner. Low-valuation buyers with type $\phi \in [(\gamma + t)/h, (\gamma + 2t)/h)$ will be uniformly licensed via the manufacturer and will pay the price of $p = \gamma + t$ to the manufacturer.

Note that when $t > 0$, the patent owner will directly license fewer buyers when the exhaustion regime allows for mixed licensing, as opposed to when it requires individualized licensing of buyers by the patent owner. Under mixed licensing, the marginal buyer type is $\phi^* = (\gamma + 2t)/h$. Under individualized licensing, the marginal buyer type will be $\phi^* = (\gamma + t)/h$.[24]

Last, substituting $\phi^* = (\gamma + 2t)/h$ into equations (10) and (11), we obtain:

$$R_c = \frac{L}{2h}(h - \gamma - 2t)(h - \gamma) \quad \text{and} \quad R_m = \frac{t^2 L}{h}. \tag{13}$$

4.3 Regime PE with prohibitive transaction costs – Same outcome as in Regime AE

Suppose the transaction cost is high enough that $t \geq (h - \gamma)/2$. Then the marginal buyer type is $\phi^* = 1$ and all buyers will be licensed uniformly via the manufacturer, since the transaction cost is so high that individualized licensing is not profitable for the patent owner. In Stage II, the patent owner will set $\lambda_m = 0$ and extract all rents from the manufacturer with a lump-sump fee of $\bar{\lambda}$. In Stage III, the manufacturer will set the monopoly price of $p = (h + \gamma)/2$. The patent owner's overall rent will be equal to R_m, which is given by equation (5).

5 Welfare Analysis

We now compare the social welfare in Regime PE to that in Regime AE.

5.1 Regime AE

Figure 1 plots the linear demand function $q(p)$ given by equation (1) and shows the composition of the total surplus in Regime AE.

[24] In Stage III, the manufacturer will set the price of $p = \gamma + t$ and in Stage II, the patent owner will set the buyer-specific license fee of $\lambda_\phi = h\phi - \gamma - t$. This is perfect price discrimination and so, ϕ^* is the value of ϕ that solves $\lambda_{\phi^*} = 0$, i.e., yields zero rent from the marginal buyer to the patent owner.

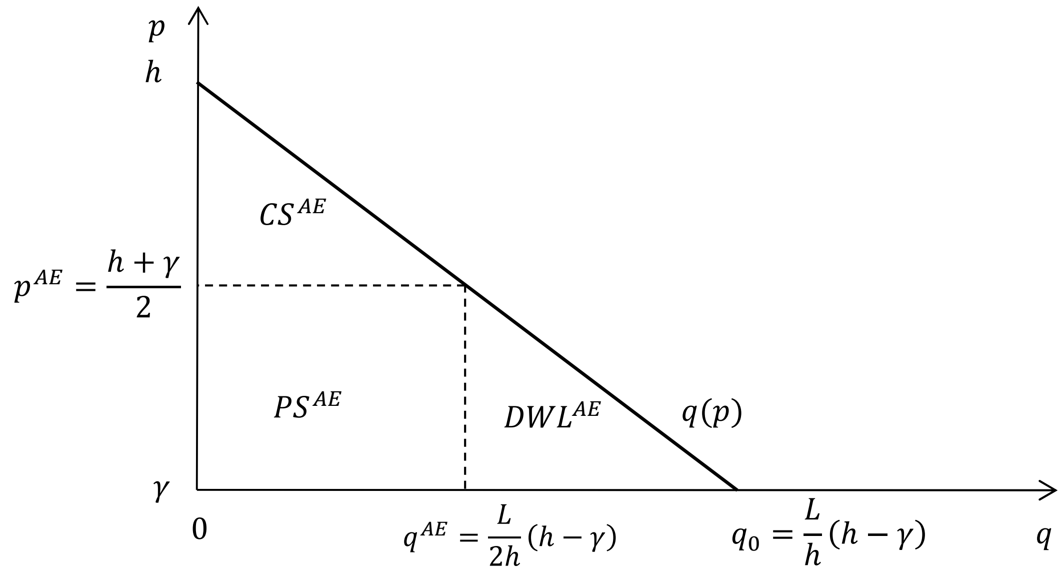

Figure 1: **The composition of the total surplus in Regime AE**

The manufacturer's price is equal to $p^{AE} = (h+\gamma)/2$. At this price, a buyer with type $\phi > p^{AE}/h$ purchases one unit of good y and earns utility $h\phi - p^{AE}$. The number of buyers who purchase good y is q^{AE}. The consumer surplus is thus given by $CS^{AE} = 0.5(h\Phi - p^{AE})q^{AE}$, or equivalently:

$$CS^{AE} = L\int_{p^{AE}/h}^{1}(h\phi - p^{AE})d\phi = \frac{L}{8h}(h-\gamma)^2. \tag{14}$$

The patent owner extracts all producer surplus from the manufacturer. The patent owner's rent is equal to $PS^{AE} = (p^{AE} - \gamma)q^{AE}$, which from equation (5) is equivalent to:

$$PS^{AE} = \frac{L}{4h}(h-\gamma)^2. \tag{15}$$

The uniform pricing creates a deadweight loss of $DWL^{AE} = S - CS^{AE} - PS^{AE}$, where S is the maximum potential surplus (i.e., the total surplus). The deadweight loss would be zero in the case of perfect price discrimination with no transaction cost. Then all consumer surplus would be extracted from buyers with type $\phi > \gamma/h$ with buyer-specific license fees of $\lambda_\phi = h\phi - \gamma$. The patent owner's rent (i.e., the producer surplus) would then be given by:

$$S = L\int_{\gamma/h}^{1}(h\phi - \gamma)d\phi = \frac{L}{2h}(h-\gamma)^2. \tag{16}$$

The deadweight loss in Regime AE is thus given by:

$$DWL^{AE} = L \int_{\gamma/h}^{p^{AE}/h} (p^{AE} - h\phi) d\phi = \frac{L}{8h}(h-\gamma)^2, \tag{17}$$

which is equivalent to $DWL^{AE} = 0.5(p^{AE} - \gamma)(q_0 - q^{AE})$, since q_0 buyers would have purchased good y at the price of γ but buyers who are willing to pay more than γ but less than p^{AE} are not served.

5.2 Regime PE

Figure 2 shows the composition of the total surplus in Regime PE. The market has two segments: (i) for low-valuation buyers with type $\phi \in (p/h, \phi^*)$, the demand is $q^L \equiv q(p; \phi^*)$, given by equation (8); and (ii) for high-valuation buyers with type $\phi \in [\phi^*, 1]$, the demand function can be expressed as the residual demand $q^H(p) = q(p) - q^L(p)$, where $q(p)$ is the total demand given by equation (1).

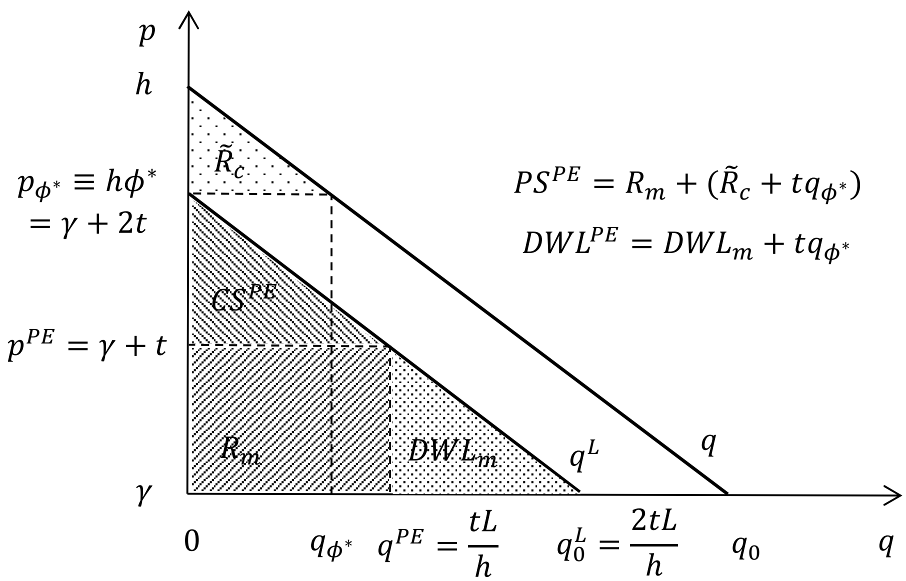

Figure 2: **The composition of the total surplus in Regime PE**

Low-valuation buyers will purchase q^{PE} units at the uniform price of $p^{PE} = \gamma + t$ and will enjoy the consumer surplus of $CS^{PE} = 0.5(p_{\phi^*} - p^{PE})q^{PE}$, which is equivalent to

$$CS^{PE} = L \int_{p^{PE}/h}^{\phi^*} (h\phi - p^{PE}) d\phi = \frac{t^2 L}{2h}. \tag{18}$$

High-valuation buyers will purchase $q_{\phi^*} = L(1-\phi^*) = L[1-(\gamma+2t)/h]$ units of y at the buyer-specific price of $p_\phi = h\phi$ and earn no consumer surplus.

The patent owner will extract all profit from the manufacturer and will earn $R_m = (p^{PE}-\gamma)q^{PE}$. The patent owner will also extract all consumer surplus from high-valuation buyers in the amount of $\tilde{R}_c = 0.5(h-h\phi^*)q_{\phi^*}$. The patent owner's overall rent from individualized licensing will be equal to R_c in equation (13), which is the sum of $\tilde{R}_c$ and the total amount of transaction costs paid by the buyers to the manufacturer, $\lambda_{\phi^*}q_{\phi^*} = (h\phi^* - \gamma - t)q_{\phi^*} = tq_{\phi^*}$. The producer surplus is equal to the patent owner's overall rent from mixed licensing, $R_T \equiv R_m + R_c$, which from equations (13) is given by:

$$PS^{PE} = \frac{t^2 L}{h} + \frac{L}{2h}(h-\gamma-2t)(h-\gamma). \tag{19}$$

In Regime PE, deadweight loss arises from (i) uniform monopoly pricing by the manufacturer and (ii) positive transaction costs in individualized licensing. The maximum potential surplus S is given by equation (16) and so, the aggregate deadweight loss is as follows:

$$DWL^{PE} = S - CS^{PE} - PS^{PE} = \frac{tL}{2h}[2(h-\gamma)-3t]. \tag{20}$$

In Figure 2, the aggregate deadweight loss is the area of the trapezoid with base $q_0 - q^{PE}$ and height $p^{PE} - \gamma$. It is equal to $DWL^{PE} = DWL_m + tq_{\phi^*}$, where $DWL_m = 0.5(p^{PE}-\gamma)(q_0^L - q^{PE})$ arises because buyers who are willing to pay less than p^{PE} will not be served and the total amount of transaction costs is tq_{ϕ^*}.

5.3 Comparison of the Regimes

When the transaction cost is prohibitive, i.e., $t \geq (h-\gamma)/2$, Regime PE is equivalent to Regime AE. Thus in what follows, we consider the case when $t < (h-\gamma)/2$. First, we compare the equilibrium prices and quantities across the two regimes. Proposition 1 follows.

Proposition 1 *It is true that $q_{\phi^*} + q^{PE} > q^{AE}$. Further, $q^{PE} < q^{AE}$, $p^{PE} < p^{AE}$, and these two cases are possible:*
(i) $q_{\phi^*} \geq q^{AE}$ and $p^{AE} \geq p_{\phi^*}$ iff $t \leq (h-\gamma)/4$;
(ii) $q^{AE} > q_{\phi^*}$ and $p_{\phi^*} > p^{AE}$ iff $t > (h-\gamma)/4$.

Fewer buyers pay uniform price in Regime PE, compared to Regime AE. But despite of this, more buyers are served in Regime PE overall, since some buyers are licensed individually by the patent owner. Not surprisingly, the number of buyers licensed individually is high when the transaction cost in individualized licensing is low enough that it satisfies $t \leq (h-\gamma)/4$. This is the case (i) at left in Figure 3. Further compared to p^{AE}, the manufacturer price in Regime PE is lower and in the case (i), the buyer-specific price is also lower.

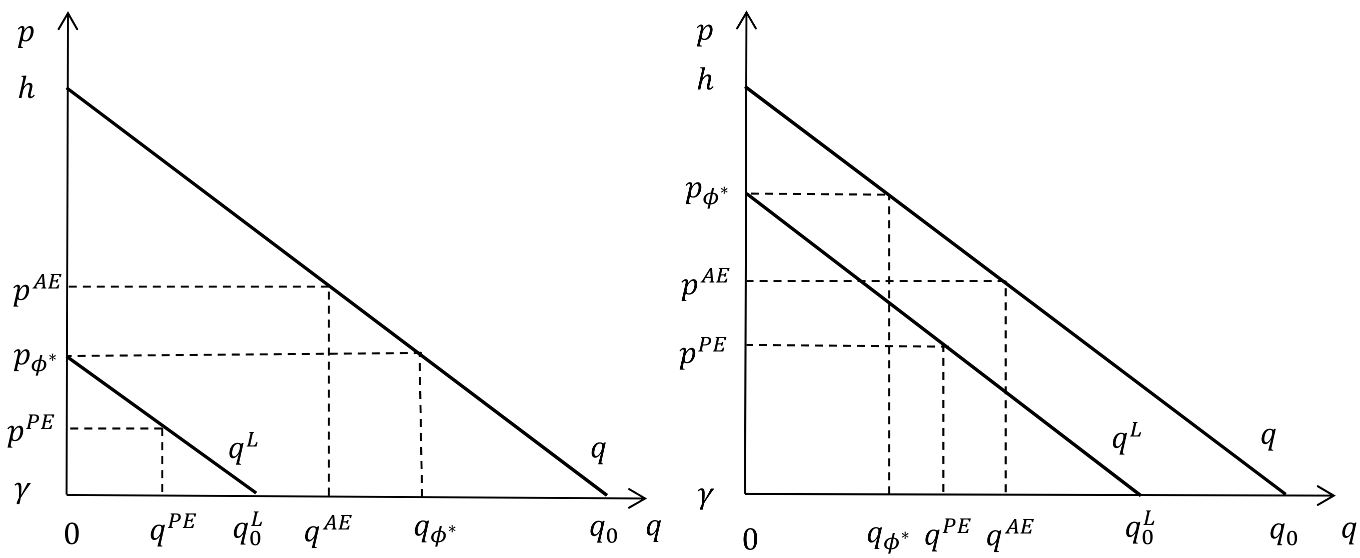

Figure 3: **Price and quantity in Regime PE and Regime AE. Case (i) when $t \leq (h-\gamma)/4$, at left and case (ii) when $t > (h-\gamma)/4$, at right**

We now compare the producer and consumer surplus across the two regimes. Proposition 2 follows.

Proposition 2 $PS^{PE} > PS^{AE}$ *and* $CS^{PE} < CS^{AE}$.

Proof: $PS^{PE} - PS^{AE} = L(h-\gamma-2t)^2/(4h) > 0$ and $CS^{PE} - CS^{AE} = L[4t^2 - (h-\gamma)^2]/(8h) < 0$.[25]

Producer surplus is higher in Regime PE, which gives the patent owner more options. The patent owner's rent is highest under mixed licensing when $t > 0$, and when $t = 0$, it is highest under individualized licensing, which allows the patent owner to extract all consumer surplus from every paying buyer while incurring no transaction cost in this case. This confirms the standard proposition that price discrimination in the context of patent licensing is optimal in the absence of transaction costs. Regime AE, by contrast, does not permit licensing of individual buyers and so, restricts the patent owner's rent.

Figure 4 shows CS^{PE} and CS^{AE}, with the low-t case (i) at left and the high-t case (ii) at right.[26] Consumer surplus is lower in Regime PE, in which only low-valuation buyers (uniformly licensed) earn consumer surplus and the number of such buyers is relatively small ($q^{PE} < q^{AE}$). Importantly,

[25] The results follow from equations (14)-(15) and (18)-(19).
[26] These two cases are defined in Proposition 1.

though, the interests of buyers are conflicting: while low-valuation buyers prefer Regime PE, high-valuation buyers prefer Regime AE.

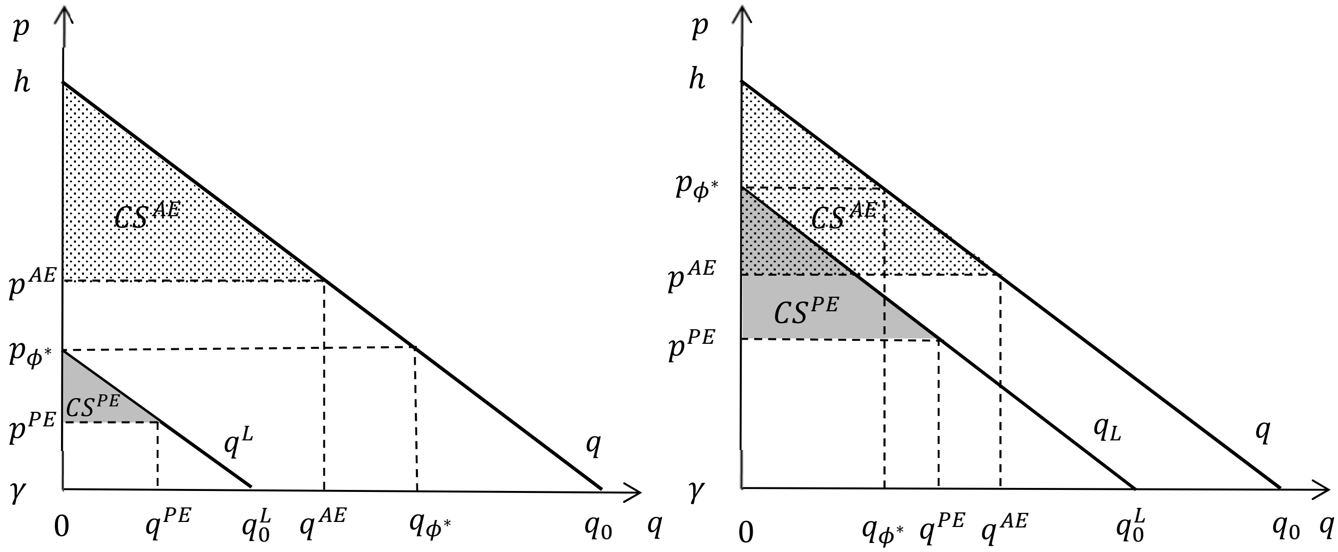

Figure 4: **Consumer surplus in Regime PE and Regime AE. Case (i) when $t \leq (h-\gamma)/4$, at left and case (ii) when $t > (h-\gamma)/4$, at right**

Last, we compare the deadweight loss across the two regimes. Proposition 3 establishes the result.

Proposition 3 *$DWL^{PE} < DWL^{AE}$ iff $0 \leq t < (h-\gamma)/6$ and $DWL^{PE} \geq DWL^{AE}$ iff $(h-\gamma)/6 \leq t \leq (h-\gamma)/2$.*

Proof: The result follows since $DWL^{PE} - DWL^{AE} = L[8t(h-\gamma) - (h-\gamma)^2 - 12t^2]/(8h)$.[27]

In Figure 5, DWL^{PE} is the area of the trapezoid with base $q_0 - q^{PE}$ and height $p^{PE} - \gamma$, and DWL^{AE} is the area of the triangle with base $q_0 - q^{AE}$ and height $p^{AE} - \gamma$. When t is small (at left), the deadweight loss is smaller in Regime PE. A large number of buyers are licensed individually in this case, which increases economic efficiency and with small t, does not add much to the deadweight loss in term of transaction cost frictions. As t rises, the number of individually-licensed buyers greatly falls, while the total amount of transaction costs rises. Consequently when t is large (at right), Regime PE produces a greater deadweight loss.

Figure 6 provides more intuition. On the right, $CS^{PE} + PS^{PE}$ is above $CS^{AE} + PS^{AE}$ when t is small, i.e., $t < (h-\gamma)/6$. Regime PE is socially optimal in this case, because the gain in producer surplus more than offsets the loss in consumer surplus. As t rises from zero on the left, the gain in producer surplus falls fast (since PS^{PE} falls fast and PS^{AE} does not change) while the loss in

[27]This follows from equations (17) and (20).

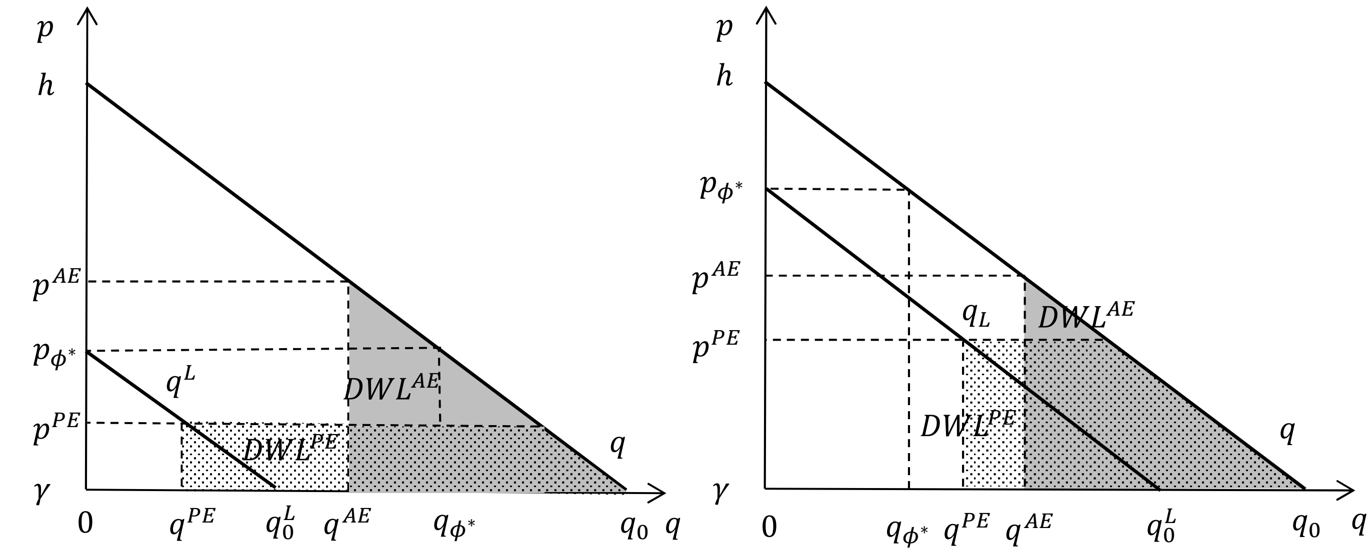

Figure 5: **Deadweight loss in Regime PE and Regime AE. Case (i) when $t \leq (h-\gamma)/4$, at left and case (ii) when $t > (h-\gamma)/4$, at right**

consumer surplus also falls but slowly (since CS^{PE} rises slowly and CS^{AE} does not change). Thus on the right, $CS^{PE} + PS^{PE}$ declines as t rises from zero and eventually falls below $CS^{AE} + PS^{AE}$. When $(h-\gamma)/6 < t < (h-\gamma)/2$, the total surplus in Regime PE is relatively small and so, Regime AE is socially optimal. When $t \geq (h-\gamma)/2$, the two regimes are equivalent.

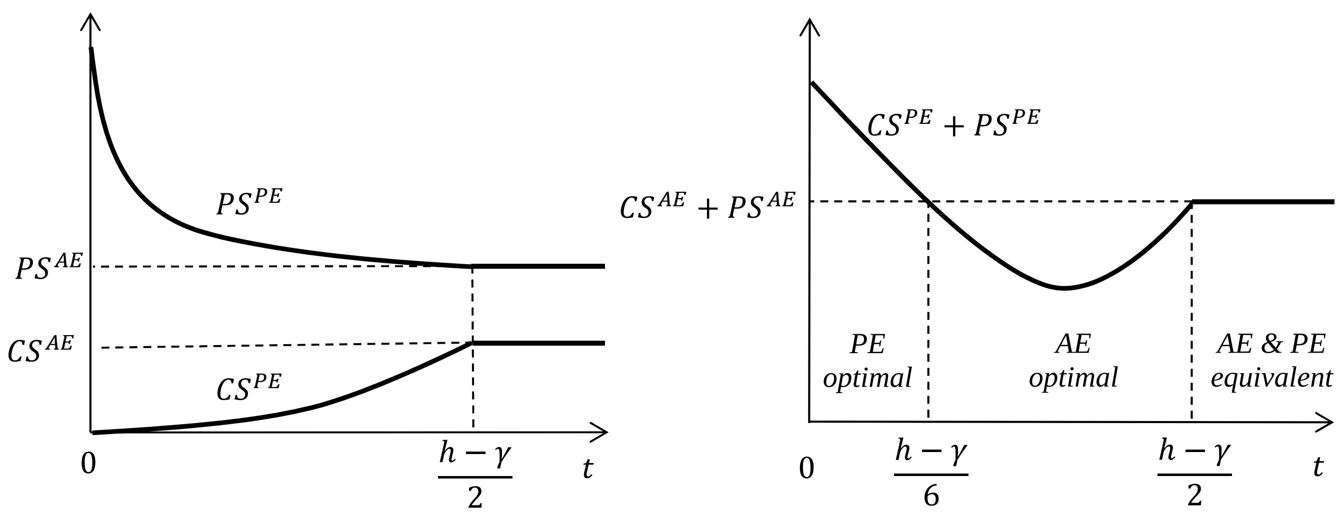

Figure 6: **Consumer and producer surplus in Regime PE and Regime AE in relation to the transaction cost**

As t falls from $(h-\gamma)/2$, the total surplus in Regime PE falls relative to that in Regime AE.[28] In other words, reducing the transaction cost from the prohibitive level increases the relative

[28] $CS^{PE} + PS^{PE}$ falls as t falls in the range $(h-\gamma)/3 < t < (h-\gamma)/2$.

inefficiency of Regime PE; it is only after the transaction cost is sufficiently reduced that its further reduction starts contributing to the relative efficiency of Regime PE. When $t = (h - \gamma)/2$, the marginal buyer type is $\phi^* = 1$ and all buyers are licensed uniformly in Regime PE; in total $q^{PE} = L(h - \gamma)/(2h)$ buyers are served at the price $p^{PE} = (h + \gamma)/2$. Now suppose t is reduced by ε, where $\varepsilon < (h - \gamma)/6$. Then from equation (12), the marginal buyer type will fall to $\phi^* = 1 - 2\varepsilon/h$, and high-valuation buyers with type $\phi \in [\phi^*, 1]$ will be licensed individually. The total number of such buyers will be equal to $2\varepsilon L/h$. At the same time, the manufacturer's price will fall to $p^{PE} = (h + \gamma)/2 - \varepsilon$ and so, the number of uniformly-licensed buyers will rise by $\varepsilon L/h$. That is, the number of individually-licensed buyers will increase twice as much as the number of uniformly-licensed buyers. A larger number of individually-licensed buyers will increase the deadweight loss from transaction cost frictions by $2\varepsilon^2 L/h$, but a larger number of uniformly-licensed buyers will reduce the deadweight loss from the manufacturer monopoly pricing by $\varepsilon^2 L/h$. The aggregate deadweight loss will thus rise.

6 Extensions

In this section, we discuss extensions to our model.

First, when assessing the welfare implications of patent exhaustion, it is important to understand how static effects interact with dynamic considerations. In a dynamic setting, producer surplus will generally drive the amount of *ex ante* innovation that the patent owner is willing to make. Indeed, if producer surplus is too low, the patent owner may not invent at all. In Section A.1 in the online appendix, we examine how the patent owner's incentive to invest in product quality (a proxy for the overall *ex ante* innovation) compares across the two regimes. We show that dynamic efficiency rises in Regime PE, and these dynamic gains in promoting *ex ante* innovation may outweigh any loss of static efficiency when the transaction cost is high. We assumed that only the patent owner invests in product quality. When third parties also invest in product quality, Regime AE could also provide dynamic benefits, to the extent that absolute exhaustion lowers the costs of patented inputs for third parties. For cumulative innovation, two competing effects could arise: stronger patent protection in the form of presumptive exhaustion increases the initial innovator's profit but could render follow-on innovation more costly.[29] The optimal tradeoff between static and dynamic efficiencies will vary widely across industries and technologies.

Second, we abstracted away from intermediaries, such as wholesalers and resellers. This is justified

[29]Denicolò (2000) assesses whether stronger patents promote welfare under cumulative innovation.

when the manufacturer sells directly to buyers, exhaustion is presumptive, and the patent owner opts out, because in this case, a buyer may be required to enter into a separate licensing agreement with the patent owner. It is also justified when intermediaries are relatively homogeneous, purchasing and licensing on behalf of groups of buyers with similar distributions of the final product valuation. In Section A.2 in the online appendix, we allow for intermediaries that purchase and license on behalf of the buyers, and assume that the intermediaries are heterogeneous in that they represent buyers of distinctly different willingness to pay for the final product. In addition, to make the model more realistic, we assume that the patent owner incurs a transaction cost when licensing to the manufacturer. Our results are qualitatively unchanged. In fact, it is more likely that Regime PE is socially optimal when each intermediary negotiates the license fees on behalf of a large number of buyers, thus saving in the transaction cost.

Third, we assumed that all parties are omniscient, particularly regarding the buyer's demand, but the patent owner may not be fully aware of the buyer's demand, particularly when the patented good is a mere component of a complex product. We consider information asymmetry in assessing the buyer's demand in Section A.3 in the online appendix. We assume that the patent owner incurs an additional cost to determine the buyer's willingness to pay for the patented good. In this context, information asymmetry acts like an increase in the transaction cost of individualized licensing and so, reduces the efficiency of Regime PE. The conclusion is the same if a buyer has difficulty determining the product value (e.g., does not know if the product is subject to license fees) and the upstream patent owner chooses to incur a cost to reveal the product value to the buyer.

Another type of information asymmetry involves uninformed buyers unknowingly agreeing to downstream restrictions on the use of purchased goods. Here, the concern is that upstream licensors can impose socially harmful terms on such buyers to extract rents. Absolute exhaustion can help solve these market defects by making the restrictions effectively unenforceable in patent actions, but a broad-brush doctrine like exhaustion is not necessary in a situation where other instruments (such as the patent misuse doctrine or the unconscionability doctrine in contract law) can be used to render the terms unenforceable.

Fourth, we assumed that the patented component x has no substitutes. In Section A.4 in the online appendix, we allow for unpatented imperfect substitutes for x. The existence of substitutes limits the power of the patent owner to act as a monopolist in setting license fees among competing manufacturers. If substitutes are perfect, then patents will provide no market power and the exhaustion doctrine—at least via its effect on a patent infringement suit—will be irrelevant. But if substitutes are imperfect, our qualitative results will still hold.

Fifth, we have assumed that buyers do not engage in arbitrage or resell used patented product on a secondary market. Indeed in the copyright context, some scholars (e.g., Heald, 2003) have justified the exhaustion doctrine on the grounds that it promotes a vigorous resale market, which benefits buyers.[30] In Section A.5 in the online appendix, we assume that there is a second-hand market in which current buyers can buy used goods (with depreciated quality), which have been previously purchased by other buyers from the patent owner under uniform licensing (in Regime PE) or uniform pricing (in Regime AE), at a discounted price. The willingness of a buyer to pay for the new good is now constrained by the consumer surplus that the used good provides, but our qualitative results still hold.

Sixth, we consider goods with multiple components patented by different patent owners (e.g., computers, mobile phones, televisions, etc.). Scholars (e.g., Lemley and Shapiro, 2007) have been concerned with so-called anti-commons problems (e.g., hold-up and royalty stacking) in which a manufacturer is confronted with royalty payments and related transaction costs that may exceed the marginal value of the component. Assuming that these problems are notable for multi-component products—which is debatable (e.g., Barnett, 2015)—exhaustion can potentially ameliorate these concerns by reducing the number of inbound licenses needed to manufacture the product. We consider multi-component products in Section A.6 in the online appendix. Our qualitative results still hold, although when the transaction costs in licensing and the number of patented components in a product are both high (especially when dealing with multiple patent owners requiring separate negotiations), Regime AE begins to be more attractive. This finding underscores our more general result that the relative efficiency of Regime PE is likely to vary widely by industry, technology, and product.

Last, we have assumed that the optimal outcome is the one that maximizes total surplus, foregoing any discussion of distributive benefits from an exhaustion regime. We find that Regime AE maximizes consumer surplus and so if the aim is to maximize consumer surplus—which is not standard in economic analysis,—then absolute exhaustion may be preferred. But we also find that low-valuation buyers prefer Regime PE. These buyers are often the least well-off and if one values their surplus more highly, then Regime PE may be optimal. Thus, despite some claims that distributive concerns support Regime AE, the reality is more nuanced.

[30] Yet in the patent context, some goods cannot be resold after they are used, or the transaction costs of resale are too high to justify the practice. For instance, pharmaceutical drugs and downloaded mobile applications have no effective resale markets.

7 Implications for Policy

Our findings explain some of the confusion surrounding the exhaustion doctrine and the differences between how exhaustion operates in the realm of copyright and patent law. In the copyright industries, where there are few intermediaries, large numbers of downstream buyers, and low prices for each work, one would expect high transaction cost inefficiencies dominating price discrimination benefits. In such industries, our model predicts the relatively vigorous enforcement of exhaustion. In the patent industries, however, there is much more variation. The mobile phone "app" industry, for example, appears closer to the copyright industries, while the semiconductor industry (with high-priced products and many intermediaries) is a better candidate for presumptive exhaustion. Like in many areas of patent law, an industry-specific set of rules is likely superior to an across-the-board rule (Burk and Lemley, 2003). Our model also shows—consistent with some qualitative scholarly treatments (e.g., Patterson, 2007)—that absolute exhaustion may make more sense with respect to end-consumers but less sense with respect to intermediaries (such as wholesalers and resellers), since the transaction cost involved in licensing these agents is relatively low.

In general, there is no *a priori* reason to favor absolute or presumptive exhaustion but rather, one regime or the other is more efficient depending on unique industry structures. Thus, assuming that judges can make relatively accurate determinations with respect to the underlying concerns—and also that contractual enforcement is generally not as efficient as patent enforcement of downstream restrictions—a contextual approach would be more fruitful than the one that precludes or allows opt-out in all cases. Based on our model, such an approach should examine three factors.

First is whether the costs in licensing downstream parties (including the negotiation, information, and search costs) are high relative to the value of the deal. A relatively high cost would support absolute exhaustion, because presumptive exhaustion would burn a large amount of social surplus in transaction cost and market frictions in this case. For instance, if a patent owner attempted to separately license each patient undergoing surgery with a particular patented surgical scalpel just prior to a surgical procedure, the transaction cost of such licensing would be high relative to the scalpel value. But if instead, the patent owner licensed large downstream manufacturers that assemble the patented component with other unpatented components en masse, the transaction cost of licensing might be relatively low. These differences in transaction costs help explain greater preference for absolute exhaustion in copyright as compared to patent law. In the copyright industries, there are few steps between the copyright owner and end-consumers, and enforcement is often against individual end-consumers; while in the patent industries, the number of steps between the patent owner and end-consumers is typically high, and enforcement is rarely against individual end-consumers.

Second, courts should determine if there is large information asymmetry between patent owners and buyers. Although this technically may be subsumed under the rubric of information and search costs, it could be difficult for courts to determine the magnitude of such costs. A useful proxy for the presence of substantial information asymmetry in this case is whether or not clear notice was provided to the downstream licensee. The absence of clear notice may support absolute exhaustion, all else being equal. With that said, because most defendants in patent infringement cases are sophisticated intermediaries, rather than individual end-consumers, the defendants typically are on actual or constructive notice of potential upstream patents that might be asserted against them. Furthermore, exhaustion applies only if the sale is authorized, which by definition requires a license between the patent owner and an upstream party in the supply chain. Sophisticated parties should be able to trace back through the supply chain to the original licensee and can demand indemnification from upstream sellers. Thus notice may be less important than appears at first blush.

Third, if transaction costs are large, courts should be more reluctant to allow opt-out when dealing with complex products comprising many separately patented components (such as computers or mobile phones), as compared to simple products comprising few patented components (such as agricultural seeds and pharmaceutical drugs). Product complexity can exacerbate the effects of high transaction costs. Also, the effects of exhaustion on complex product innovation are far from clear. Absolute exhaustion may reduce the surplus accruing to upstream patent owners, but it may also reduce the cost of using patented components in follow-on innovation and further commercialization by downstream parties, which is often required to achieve viability in complex-product industries (Sichelman, 2010).

Last, we note that there are other concerns, such as those premised on autonomy or distributive justice. For example, if courts wish to further the interests of consumers at the expense of overall welfare, then different considerations may apply.

8 Conclusion

This paper examined how a shift in domestic patent policy from absolute to presumptive exhaustion (which presumes exhaustion but allows the patent owner to opt-out via contract) affects social welfare. It offered the first economic model of domestic patent exhaustion that allows for two types of licensing of buyers by the patent owner—individualized licensing and uniform licensing via the manufacturer—and incorporates transaction cost in buyer-specific patent licensing. The transaction cost, which includes the time and effort involved in negotiating license fees and executing licensing agreements with individual buyers, increases the unit cost of the final good.

The results show that when the transaction cost is low, presumptive exhaustion is socially optimal, because it allows welfare-enhancing price discrimination via individualized licensing. Conversely when the transaction cost is high, presumptive exhaustion leads to a greater loss of static efficiency, because the transaction cost frictions more than offset the benefit of price discrimination. Relaxing our model's key assumptions by-and-large does not affect our results.

Our findings confirm and expand upon qualitative results in the literature. First, we confirm the proposition in Mulligan (2013, 2016) that absolute exhaustion may reduce rent dissipation when the transaction cost of licensing is high, because it prevents the patentee from "burning up" large amounts of surplus via transaction costs in individualized licensing. We also show that absolute exhaustion can reduce product prices for buyers with high willingness to pay (Katz, 2016). Also, our results support the arguments in Kieff (2008) and Katz (2016) that absolute exhaustion can reduce social efficiency, since it prevents price discrimination via downstream licensing, and clarify that this occurs when the transaction cost in individualized licensing is low. On the other hand, our findings do not support the proposition in Layne-Farrar (2011) and Layne-Farrar et al. (2014) that absolute exhaustion is likely to generate welfare losses in the face of transaction costs; in contrast, we show that absolute exhaustion *decreases* static inefficiency when the transaction cost in individualized licensing is high.

Whether absolute or presumptive exhaustion is more socially optimal is ultimately an empirical question that turns on the specific circumstances at hand. We suggest that courts adopt a contextual approach, allowing opt-out depending on the specific circumstances and considering three factors: *i*) transaction costs, including negotiation, search, and information costs; *ii*) information asymmetry; and *iii*) product complexity.

References

[1] Barnett, J.M., 2015. The Anti-Commons Revisited. *Harvard Journal of Law & Technology*, 29(1): 164-203.

[2] Brown, D.K., and Norman, G., 2003. Optimal Intellectual Property Rights Exhaustion and Humanitarian Assistance during a National Health Emergency. *Working Paper 0314*, Department of Economics, Tufts University.

[3] Burk, D.L. and Lemley, M.A., 2003. Policy Levers in Patent Law. *Virginia Law Review*, 89(7): 1575-1696.

[4] Carrier, M.A., 2004. Cabining Intellectual Property through a Property Paradigm. *Duke Law Journal*, 54(1): 1-145.

[5] Denicolò, V., 2000. Two-Stage Patent Races and Patent Policy. *The RAND Journal of Economics*, 31(3): 488-501.

[6] Grossman, G.M. and Lai, E.L.-C., 2008. Parallel Imports and Price Controls. *The RAND Journal of Economics*, 39(2): 378-402.

[7] Heald, P.J., 2003. Mowing the Playing Field: Addressing Information Distortion and Asymmetry in the TRIPS Game. *Minnesota Law Review*, 88: 249-314.

[8] Hovenkamp, H., 2011. Post-Sale Restraints and Competitive Harm: The First Sale Doctrine in Perspective. *NYU Annual Survey of American Law*, 66: 487-547.

[9] Hovenkamp, H., 2016. Patent Exhaustion and Federalism: A Historical Note. *Virginia Law Review Online*, 102: 25-33.

[10] Ivus, O. and Lai, E.L.C., 2018. Patent Exhaustion Policy and International Production Sharing: Winners and Losers? *CESifo Working Paper*.

[11] Katz, A., 2016. The Economic Rationale of Exhaustion: Distribution and Post-Sale Restraints, in *Research Handbook on IP Exhaustion and Parallel Imports* (Irene Calboli & Edward Lee, eds.), Edward Elgar: 23-43.

[12] Kieff, F.S., 2008. Quanta v. LG Electronics: Frustrating Patent Deals by Taking Contracting Options off the Table. *Cato Supreme Court Review*, 315-330.

[13] Layne-Farrar, A. and Llobet, G. and Padilla, J., 2014. Patent Licensing in Vertically Disaggregated Industries: The Royalty Allocation Neutrality Principle. *Communications & Strategies*, 1(95): 61-84.

[14] Layne-Farrar, A., 2011. An Economic Defense of Flexibility in IPR Licensing: Contracting around First Sale in Multilevel Production Settings. *Santa Clara Law Review*, 51: 101-137.

[15] Lemley, M.A. and Shapiro, C., 2007. Patent Holdup and Royalty Stacking. *Texas Law Review*, 85: 1991.

[16] Maskus, K.E. and Chen, Y., 2004. Vertical Price Control and Parallel Imports: Theory and Evidence. *Review of International Economics*, 12(4): 551-570.

[17] Meurer, M.J., 2003. Controlling Opportunistic and Anti-Competitive Intellectual Property Litigation. *Boston College Law Review*, 44: 509-544.

[18] Mulligan, C., 2013. A Numerus Clausus Principle for Intellectual Property. *Tennessee Law Review*, 80: 235-883.

[19] Mulligan, C., 2016. Personal Property Servitudes on the Internet of Things. *Georgia Law Review*, 50: 1121-1168.

[20] Patterson, M.R., 2007. Contractual Expansion of the Scope of Patent Infringement Through Field-of-Use Licensing. *William and Mary Law Review*, 49: 157-228.

[21] Perzanowski, A. and Schultz, J., 2011. Digital Exhaustion. *UCLA Law Review*, 58: 889-946.

[22] Saggi, K., 2013. Market Power in the Global Economy: The Exhaustion and Protection of Intellectual Property. *The Economic Journal*, 123(567): 131-161.

[23] Saggi, K., 2014. Regional Exhaustion of Intellectual Property. *International Journal of Economic Theory*, 10(1): 125-137.

[24] Shaked, A. and Sutton, J., 1982. Relaxing Price Competition through Product Differentiation. *The Review of Economic Studies*, 49(1): 3-13.

[25] Sichelman, Ted M., 2010. Commercializing Patents. *Stanford Law Review*, 62(2): 341-413.

[26] Skladony, W.P., 2007. Commentary on Select Patent Exhaustion Principles in Light of the LG Electronics Cases. *IDEA*, 47(3): 235-299.

[27] Valletti, T.M., 2006. Differential Pricing, Parallel Trade, and the Incentive to Invest. *Journal of International Economics*, 70(1): 314-324.

[28] Valletti, T.M. and Szymanski, S., 2006. Parallel Trade, International Exhaustion and Intellectual Property Rights: A Welfare Analysis. *The Journal of Industrial Economics*, 54(4): 499-526.

[29] Zheng, W., 2016. Exhausting Patents. *UCLA Law Review*, 63: 122-208.