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An Economic Model of Patent Exhaustion

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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. This paper offers the first formal economic model of domestic patent exhaustion that incorporates transaction costs in consumer licensing, and examines how a shift in patent policy from absolute to presumptive exhaustion, in which the patent owner can opt- out of exhaustion via contract, affects social welfare. The results show that when transaction costs are low, presumptive exhaustion is socially optimal, because it allows welfare-enhancing price discrimination via downstream licensing. Conversely, when transaction costs are high, the regime of presumptive patent exhaustion leads to a greater loss of static efficiency, because transaction cost frictions offset the benefits of price discrimination, but dynamic benefits in promoting ex ante investment in product quality may outweigh any static inefficiencies.

JEL-Codes: F100, O310.

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

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1 Introduction

1.1 Background on the Doctrine of Exhaustion

When a retailer purchases patented goods from wholesalers, the retailer typically expects it can resell the goods to consumers or downstream buyers. 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 wholesaler 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 in order to preserve their right to collect additional license fees. Whether and when 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.

Two recent U.S. Supreme Court cases—*Quanta Computer, Inc. v. LG Electronics, Inc.* (2008) and *Bowman v. Monsanto* (2012)—did little to dispel the confusion in this area of law, which is of fundamental importance in numerous industries, ranging from pharmaceuticals to semiconductors to software. More recently, in *Lexmark Int’l, Inc. v. Impression Products, Inc.* (2016), the United States Court of Appeals for the Federal Circuit—which decides all appeals related to patent cases in the United States—reconsidered the scope of patent exhaustion. The facts of the case were that Impression Products had purchased printer cartridges from Lexmark’s customers within and outside the United States, but was subject to contractual restrictions on Impression’s reuse or resale of the cartridges. In violation of those restrictions, Impression altered and resold the products in the United States, undercutting Lexmark and its domestic wholesalers in the process. At issue was whether Impression’s actions constituted infringement of Lexmark’s patents or whether the doctrine of patent exhaustion applied to end Lexmark’s patent rights upon its authorized sale of the cartridges to Impression.

Two specific questions were presented in *Lexmark* regarding patent exhaustion: (1) do the contractual restrictions imposed by Lexmark on Impression’s purchase override the doctrine of patent exhaustion, so as to make Impression liable for patent infringement? (so-called contractual “opt-out” of “domestic exhaustion”); and (2) even if patent exhaustion applies to purchases made by Impression within the United States, does it apply to Impression’s purchases *outside* of the United States, so that Impression can import the cartridges into the United States and resell without being liable for patent infringement? (so-called “international exhaustion”).

Lexmark’s case against Impression attracted the attention of a number of major players in patent-dependent industries. Over thirty *amicus curiae* briefs were filed at the Federal Circuit by outsiders to aid the Court’s decision. On the one hand, there were firms like Intel, LG Electronics, Samsung, eBay, Amazon and others that are reliant on patent-protected inputs to the products they produce or sell. These firms argued that their products include components from numerous suppliers, and that allowing upstream patent owners to “opt out” so as to impose downstream licenses would require them to “trace the patent rights of every component it purchases and then negotiate appropriate license arrangements with the component manufacturer (as well as any sub-component manufacturer).” On the other side were opponents to a broader scope of patent exhaustion, including the Pharmaceutical Research and Manufacturers of America (PhRMA), the Biotechnology

Industry Organization (BIO), and the Intellectual Property Owners Association (IPO). These organizations represent firms and individuals that depend substantially on patent rents, and have argued that the patent exhaustion doctrine should remain limited so as to allow firms to engage in domestic and international price discrimination, particularly without fear of cheaply sold imports emerging in U.S. markets and undercutting their domestic trade.

In a 10-2 *en banc* decision released in February 2016, the Federal Circuit ruled in Lexmark’s favor, holding that upstream patent owners may opt out of patent exhaustion through contractual restrictions, and that patent rights are not exhausted by an authorized sale abroad (even where no reservation of rights accompanies the sale). Following Impression’s petition to appeal to the U.S. Supreme Court, the U.S. Solicitor General intervened, requesting the Court reconsider the lower court’s decision on both the ability of patent owners to opt out of exhaustion and whether international exhaustion is applicable. In its written submissions, the Obama Administration argued in favor of absolute domestic exhaustion (i.e., mandatory exhaustion, which effectively precludes opt-out) but presumptive international exhaustion (i.e., in which the patent owner can opt-out via contract). In December 2016, the Supreme Court granted certiorari. The case was argued on March 21, 2017, and is awaiting a final decision from the Court.

Against that background, it is clear that U.S. patent exhaustion policy is a serious and contentious policy issue, and carries with it significant consequences for trade and welfare, both domestic and abroad. Yet the actual policy implications of patent exhaustion and the *Lexmark* appeal are far from clear.¹

1.2 A Brief Description of Our Model and Findings

This paper examines how a shift in patent policy from absolute (mandatory) to opt-out (presumptive) patent exhaustion (i.e., in which the patent owner can opt-out via contract) affects social welfare. We develop a closed-economy model in which there exists one differentiated component

¹If patent infringement occurs because a licensee has exceeded the limitations in a license agreement directly executed between the patent owner and the licensee, in addition to the patent infringement claim, the patent owner may be able to assert a contract claim. Nonetheless, patent claims offer a wider array and scope of remedies than contract claims, particularly injunctive relief. Moreover, a contract claim usually affords no consequential or punitive damages. Patent cases have the additional advantage of being tried in federal courts with a relatively uniform body of nationwide law, which is often preferable 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. For instance, in *Lexmark*, the patent owner could not assert a contractual claim against the alleged infringer, because the alleged infringer purchased the products-at-issue from the patent owner’s customers rather than patent owner itself. Although a patent owner can attempt to impose a “nested” set of downstream contracts so as to ensure privity with downstream infringers, achieving as much is not a certainty, and in the very least, raises transaction costs. This is especially so if the contractual “intermediaries” between the patent owner and downstream infringers are ordinary customers, which patent owners are typically loath to sue because of negative repercussions in the marketplace. As such, it is not surprising that patent owners tend to favor patent infringement claims and 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. To the extent contractual actions allow patent holders to “imperfectly” enforce downstream restrictions, our model and results would not change qualitatively. Rather, it would merely reduce the size of the effects we describe.

that is patented by a third-party patent holder and for which no substitute exists. Upstream manufacturers use the patented component in their final good production, and licenses must be obtained from the patent owner for a royalty fee. *Ex ante*, there is a large number of identical, potential manufacturers of the good, but because the patent owner acts to maximize licensing fees, it licenses the component to only one manufacturer, thus making the manufacturer a monopolist in the market for the good that it produces and sells to consumers.

Consumers, who are the end-users of the good, have vertical preferences and differ in their willingness to pay for the higher quality of the good.² The price a consumer is charged for the good depends on the legal regime regarding patent exhaustion. In a regime of absolute patent exhaustion, when the manufacturer sells the good to the consumer, the patent holder loses all rights to proceed against consumers for patent infringement; an authorized purchase from the manufacturer gives a consumer the right to use and re-sell the good without paying any additional license fees to the patent holder. However when patent exhaustion is presumptive and the patent holder opts out, consumers must enter into a license with the patent holder or risk patent infringement; a license from the patent holder only provides a right to use the good but not to resell it.

We assume that the patent owner incurs a positive per-unit transaction cost when licensing to consumers, and does not incur a transaction cost when licensing to the manufacturer.³ Depending on the regime regarding patent exhaustion, the patent holder chooses between setting consumer-specific license fees, a manufacturer license fee, or some combination of the two (i.e., mixed licensing). Under pure consumer licensing, the patent owner can capture the entire total surplus but must internalize the additional transaction cost. Under pure manufacturer-licensing, the patent owner saves in transaction costs but fails to capture the entire total surplus via the manufacturer, since the manufacturer sets a uniform price for all consumers.⁴

The results show that absolute exhaustion results in a greater loss of static efficiency compared to opt-out patent exhaustion when transaction costs are low. This is because unlike the regime of opt-out exhaustion, the regime of absolute exhaustion disallows welfare-enhancing price discrimination via downstream licensing; and the benefits of price discrimination dominate transaction cost frictions provided transaction costs are sufficiently low. Conversely, when transaction costs are high, the regime of opt-out patent exhaustion is inferior in static terms. Here, the patent

²More generally, there exist two types of consumers: “end-consumers,” who are the end-users of the good, and “intermediary-consumers” (e.g., the downstream manufacturers, wholesalers, and resellers, etc.), which purchase, resell and license (if need be) the good on behalf of end-consumers. We focus our analysis on the end-consumers, but discuss how allowing for the intermediaries would affect our results in Section 5.2.

³We assume that we are dealing with a very large class of end-consumers for which transaction costs (either directly or through an intermediary) are very large relative to the single licensing deal that the patent holder strikes with the manufacturer, such that the manufacturer licensing costs can be ignored. We relax the assumption of zero transaction costs between the manufacturer and the patent holder in Section 5.2.

⁴To be certain, the “manufacturer licensing” in a regime of presumptive exhaustion is somewhat different from the “manufacturer licensing” in a regime of absolute exhaustion. In a regime of presumptive exhaustion, the patent holder’s right to exclude others from selling the good does not exhaust after the manufacturer sells the final good to any end-consumer. Thus, the patent holder can price-discriminate between the high-valuation and low-valuation consumers without fear of arbitrage. In a regime of absolute exhaustion, all patent holder’s rights are exhausted after an authorized sale by the manufacturer. Thus after the manufacturer sells the good to the consumer, the latter has the right to re-sell it and so, neither the patent holder nor the manufacturer can price discriminate between consumers. We address arbitrage in Section 6.1, *infra*.

holder’s single-minded goal of maximizing its rent consumes large amounts of surplus via downstream licensing transaction costs—so much so that the transaction cost frictions more than offset the benefits of price discrimination.

We further extend our model to account for *ex ante* investment in product quality, licensing via heterogeneous intermediaries, manufacturer transaction costs, information asymmetries in assessing consumer demand, consumer switching costs, substitutes for the patented component, and multi-component products. We find that dynamic efficiency rises in the regime of opt-out patent exhaustion, and these dynamic gains in promoting *ex ante* investment in product quality may outweigh any loss of static efficiency in the opt-out exhaustion regime when transaction costs are high. Opt-out patent exhaustion is also more likely to dominate in terms of static efficiency when licensing is via heterogeneous intermediaries, with each intermediary negotiating the license fees on behalf of a large number of consumers. On the other hand, absolute patent exhaustion is more likely to dominate in terms of static efficiency when there is information asymmetry in assessing consumer demand, which acts like an increase in transaction costs. Allowing for positive manufacturer transaction costs does not affect our results. Likewise, easing consumer switching costs does not alter our findings across the variety of transactions engaged in by patent owners. Furthermore, our results continue to hold qualitatively when we allow for substitutes for the patented component or consider goods comprising multiple patented components.

1.3 Previous Scholarship on Patent Exhaustion

The legal literature has qualitatively examined the arguments for and against absolute exhaustion. A common justification for exhaustion found in judicial decisions and legal scholarship (e.g., Skladony, 2007) is that once the patent holder is paid by a licensee for the use of a patented good, he has no right to further payment. As the U.S. Supreme Court stated in *Bloomer v. Millinger* (1863), patent holders “are entitled to but one royalty for a patented machine.” However, like arguments against “double taxation,” such contentions are more conclusory than evincible. One argument is that a single payment is sufficient reward to induce invention, yet there is no empirical or theoretical basis for this assertion. Perhaps, as the Federal Circuit stated in *Mallinckrodt, Inc. v. Medipart, Inc.* (1992), the patent holder 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. Also, exactly how much surplus is necessary to induce the optimal level of innovation is itself a hotly contested matter, and there is no *a priori* reason to assume a single license to an intermediate manufacturer, reseller, or purchaser is sufficient to induce optimal investment.

Another justification for exhaustion is the general aversion to so-called restraints on alienation; namely, that it is economically efficient to generally 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) argue that exhaustion can reduce situations of consumer “lock in” and diminish switching costs, by allowing users to more easily switch to competing technologies. Mulligan (2016) argues that exhaustion can reduce the rent dissipation that may occur when the transaction costs of licensing are high. 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).⁵ In this regard, allowing patent owners to opt out of exhaustion allows for price discrimination, which may reduce deadweight loss and increase incentives to innovate. Patent exhaustion may also 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).⁶

The qualitative literature provides no clear framework to resolve the issue of whether absolute exhaustion increases or decreases overall welfare. Surprisingly, while numerous scholars have examined the exhaustion doctrine, very few have advanced a formal model of domestic patent exhaustion. Maskus and Chen (2004), Valletti (2006), Valletti and Szymanski (2006), Grossman and Lai (2008), and Saggi (2013, 2014) are valuable contributions because they offer models of patent exhaustion, but these models are all limited to parallel trade among countries and the effects of international exhaustion cannot be easily adapted to the case of domestic exhaustion.⁷ Brown and Norman (2003) discuss domestic exhaustion, but merely in the context of international trade. It appears that only one unpublished paper, Layne-Farrar et al. (2010), formally models domestic patent exhaustion. The paper proposes a model where 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 critical issue of transaction costs. The authors discuss transaction costs outside the context of their model and conclude that “in the face of transaction costs and frictions, a strict interpretation of first sale patent exhaustion is likely to generate welfare losses in the economically justified reward and efficiency dimensions of licensing.”

1.4 Our Contribution

Our paper’s key contribution to the literature is a formal economic model of domestic patent exhaustion that explicitly incorporates transaction costs. Contrary to Layne-Farrar et al.’s (2010) remark, we find that absolute patent exhaustion may generate welfare gains when transaction costs are high. Conversely, when transaction costs are low, presumptive exhaustion—which allows for contractual opt-out—is most likely superior.

In our model, the benefits of absolute exhaustion will depend on unique industry structures. Our findings help explain some of the confusion surrounding the doctrine, and the differences between how exhaustion operates in the realm of copyright law as opposed to patent law. In the copyright

⁵Unlike horizontal restraints, vertical restraints do not constrain direct competitors (Meurer, 2003).

⁶Of course, these effects depend upon a restrictive exhaustion doctrine that precludes patent owners from opting-out of exhaustion via contract. On the other hand, such contractual terms can be separately policed via the patent misuse doctrine, or via antitrust doctrine itself, which can function in a more tailored fashion. We abstract away from these anticompetitive issues here and address exhaustion doctrine’s most basic concern—namely, the ability of the downstream consumer simply to resell or use the patented good (without price or other restrictions) in the absence of a separate license from the patent owner.

⁷Valletti (2006) and Valletti and Szymanski (2006) model the tradeoff between the static benefits of *ex post* allocation resulting from exhaustion against the dynamic, *ex ante* costs of reduced product quality because of lower investment.

industries, where there are few intermediaries, large numbers of downstream consumers, and low prices for each copyrighted work, one would expect high transaction cost inefficiencies which would tend to dominate price discrimination benefits. In such industries, our model predicts the relatively vigorous enforcement of exhaustion in copyright law under the so-called first-sale doctrine. 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—which involves high-priced products and many intermediaries—appear a better candidate for opt-out exhaustion. Like many areas of patent law, an industry-specific set of rules is likely superior to an across-the-board rule (see 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 downstream manufactures, wholesalers, and resellers), in view of the relative transaction costs of these agents.

The rest of the paper proceeds as follows. Section 2 sets up our model and outlines four possible legal regimes regarding patent exhaustion: (1) absolute exhaustion, which mandates that all patent rights are exhausted upon sale by the manufacturer; (2) opt-out exhaustion, which allows the patent holder to opt-out of exhaustion via contract; (3) opt-out no exhaustion, which allows the patent holder to opt-out of no exhaustion via contract; and (4) absolute no exhaustion, which requires consumers to acquire a license from the patent holder to use the good, even in the face of a contractual provision otherwise. Although the last two regimes essentially do not occur in practice, we analyze them for completeness. Section 3 solves for the equilibrium prices and license fees under each of the four exhaustion regimes, and Section 4 compares the social welfare among the regimes. In Section 5, we discuss how our results may change when we relax our key assumptions. Section 6 discusses qualifications to our model, and the implications of our results taking into account these qualifications. Section 7 concludes.

2 Model Set-up

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

2.1 Preferences

Consumers have vertical preferences and differ in their type ϕ , which determines their willingness to pay for goods of a certain quality.⁸ A consumer 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 consumer 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 $[0, \Phi]$ and so, the probability density of consumers per

⁸The 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 (2017).

type is $1/\Phi$. Given uniform price p , the quantity demanded q is linear and is given by the number of consumers who purchase good y :

$$q = L \int_{\frac{p}{h}}^{\Phi} \left[\frac{1}{\Phi} \right] d\phi = \frac{L}{\Phi} \left[\Phi - \frac{p}{h} \right]. \quad (1)$$

2.2 Production and Sales

The production of good y requires one differentiated component, x , which is patented by a third-party patent holder.⁹ The patent provides market power to the patent holder in the sense that there are no suitable substitutes for x .¹⁰ Besides the component x , labor and materials are the only other inputs required to produce y . The unit cost (inclusive of labor and materials cost but exclusive of the possible license fee for x) of producing y is assumed to be constant and equal to γ . The fixed cost of production of good y is zero.

We assume that a potential manufacturer of y will obtain a license from the patent holder 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 always less costly to negotiate a license *ex ante* than to risk being sued for patent infringement. The manufacturer will pay a license fee of λ_m per unit of x plus a lump sum of $\bar{\lambda}$ to the patent holder.

Ex ante, there is a large number of identical potential manufacturers of good y competing for the use of x to produce y . Because the patent owner desires to extract as much rent as possible from license fees, he will license his component x to one manufacturer, thus making this manufacturer a monopolist in the market for the good y that it sells.¹¹

For simplicity, we further assume that the transaction costs between the patent owner and manufacturer in executing the license are effectively zero (at least when compared to the total transaction costs that will be borne between the consumers and the patent owner in the event the consumer needs to obtain a license).¹²

There are four possible legal regimes regarding patent exhaustion:

Regime (1) - Absolute Exhaustion: In a regime of absolute (or mandatory) exhaustion, when the manufacturer sells the good to the consumer, regardless of the patent holder's desires, the patent holder loses all rights to proceed against consumers for patent infringement.

⁹Although we refer to patents here, our model is also generally applicable to exhaustion in the copyright context.

¹⁰We relax this assumption in Section 5.5.

¹¹We assume the manufacturer has the capacity and distribution network to satisfy the total demand. The patent holder has an *ex ante* incentive to license only to one manufacturer, because doing so maximizes the patent holder's rents from license fees. If the patent holder were to license its component x to more than one manufacturer, then the licensees would compete with each other, and this would reduce the patent holder's overall rent.

¹²This assumption will hold when the number of consumers, L , is fairly large and heterogeneous (in terms of their willingness to pay), so that there is value in negotiating individual consumer licenses when legally permissible. We relax this assumption in Section 5.2, where we assume that the patent holder incurs positive transaction costs when licensing to the manufacturer.

Regime (2) - Opt-Out Exhaustion: In a regime of opt-out (or presumptive) exhaustion, the patent holder loses all rights to proceed against consumers for patent infringement unless the patent holder imposes downstream contractual restrictions on consumers via the manufacturer. If the patent holder imposes such restrictions, consumers must enter into a license with the original seller of the patented component (the patent holder) or risk patent infringement.

Regime (3) - Opt-Out No Exhaustion: In a regime of opt-out no exhaustion, absent an opt-out of no exhaustion by the patent holder, consumers, 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 holder or risk patent infringement.

Regime (4) - Absolute No Exhaustion: In a regime of absolute no exhaustion, regardless of the patent holder's desires, consumers, 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 holder or risk patent infringement.

The issue pending at the U.S. Supreme Court in *Lexmark* is whether to adopt Regime (1) or (2).¹³ Nonetheless, for completeness and ease of exposition, we also analyze Regimes (3) and (4).

3 Equilibrium

The model has three stages. In Stage I, the government sets the exhaustion regime. In Stage II, the patent holder sets license fees paid by the manufacturer—i.e., a fee of λ_m per unit of x plus a lump-sum fee of $\bar{\lambda}$ —and if there is no exhaustion, potentially also license fees paid by consumers. In Stage III, the manufacturer sets the price of the good to be sold to consumers. The model is solved using backward induction. This implies that in setting a price p for the good, the manufacturer takes into account license fees, chosen by the patent holder in Stage II. We first analyze Regimes (1) and (4), and then allow for the possibility of opt-out.

3.1 Regime (1) - Absolute Exhaustion

The manufacturer price is set to maximize the manufacturer's profit Π (exclusive of the lump-sum license fee paid to the patent holder), which is given by:

$$\Pi = [p - c]q = [p - \lambda_m - \gamma] \frac{L}{\Phi} \left[\Phi - \frac{p}{h} \right], \quad (2)$$

¹³To be certain, even if the Court adopts an opt-out regime, it may limit the scope of opt-out to certain market activities. For instance, the Court may hold that certain uses may be prohibited absent a license (e.g., combination of a patented good with certain non-approved products) but other uses are always permissible (e.g., resale of the patented good). Here, we focus on whether opt-out allows resale of the patented good absent a license.

where the second equality follows from equation (1) and the fact that the total unit cost of producing y is $c = \lambda_m + \gamma$. Differentiating Π with respect to p and setting the result to zero, we find the profit maximizing price:

$$p = \frac{1}{2}(h\Phi + \lambda_m + \gamma). \quad (3)$$

The price p is the monopoly price for the good, because there are no other manufacturers (which is sensible given that we are assuming a good with one substantial, differentiated and patented technological component). At this price, from equation (1), the aggregate quantity demanded is

$$q = \frac{L}{\Phi} \left[\Phi - \frac{1}{2h}(h\Phi + \lambda_m + \gamma) \right] = \frac{1}{2h} \frac{L}{\Phi} (h\Phi - \lambda_m - \gamma). \quad (4)$$

In Stage II, the patent holder sets the license fee λ_m plus a lump-sum fee $\bar{\lambda}$ (equal to Π) to extract all the rents from the manufacturer. This rent, called R_m , is equal to the per unit license fee times the aggregate quantity demanded at the monopoly price plus the manufacturer's profit:

$$R_m = \lambda_m q + \Pi = (p - \gamma)q = \frac{1}{2}(h\Phi + \lambda_m - \gamma) \left[\frac{1}{2h} \frac{L}{\Phi} (h\Phi - \lambda_m - \gamma) \right]. \quad (5)$$

Differentiating R_m with respect to λ_m and setting the derivative to zero, we find that the optimal license fee per unit of x is zero:¹⁴

$$\lambda_m = 0. \quad (6)$$

Substituting the optimal per unit license fee of $\lambda_m = 0$ into (2)-(4), we find:

$$p = \frac{1}{2}(h\Phi + \gamma); \quad q = \frac{1}{2h} \frac{L}{\Phi} (h\Phi - \gamma); \quad \text{and} \quad \Pi = \frac{1}{4h} \frac{L}{\Phi} (h\Phi - \gamma)^2. \quad (7)$$

Thus, the lump-sum license fee equals the patent holder's rent and is given by:

$$\bar{\lambda} = R_m = \Pi = \frac{1}{4h} \frac{L}{\Phi} (h\Phi - \gamma)^2. \quad (8)$$

The patent holder maximizes its profits with an up-front, lump-sum royalty. This is expected given that both parties are risk-neutral, the patent holder has all of the bargaining power, and the total profit can be calculated in advance. If, for example, the license fee were paid on a per-unit basis with no lump-sum component and were set such that $\lambda_m = p - \gamma$, the manufacturer's optimal response would be to produce nothing (as it knows that it would end up earning no profit) and so, the patent holder's rent would be zero. When the license fee has a lump-sum component, $\bar{\lambda}$, the patent holder is able to extract maximum rents from the manufacturer with the license fee. Since *ex ante* there is a large number of identical potential manufacturers of x , the competition among them will allow the patent holder to adjust $\bar{\lambda}$ so as to make the chosen manufacturer break even: $\bar{\lambda} = \Pi$. Consequently, the patent holder recovers all profit from the manufacturer and earns the rent of $R_m = \Pi$.

¹⁴The second order condition for maximization is satisfied as $\partial^2 R_m / \partial \lambda_m^2 = -1 < 0$.

3.2 Regime (4) - Absolute No Exhaustion

Regime (4) of absolute no exhaustion does not allow for manufacturer sublicensing of consumers and instead, requires the patent owner to negotiate a license with each consumer. The patent holder can launch an infringement suit against any consumer who does not obtain such a license. For simplicity, we assume that a license from the patent holder only provides a right to use the good but not to resell it. Precluding resale implies arbitrage will not occur—i.e., consumers cannot resell the good without the patent holder's permission—and the patent holder can engage in perfect price discrimination. As such, in Stage II, the patent holder sets the consumer-specific license fees λ_ϕ which depends on the consumer type ϕ . We assume that all consumers will obtain a license, because they can accurately estimate the probabilities of losing a patent infringement suit, and given litigation costs, it is less costly to negotiate a license *ex ante*.

Zero transaction costs in licensing

Let $\lambda_T \equiv \lambda_m + \lambda_\phi$ be the total license fee that the patent holder receives per unit of x . Assume for now that licensing to downstream consumers is costless for a patent holder. In this case, in Stage II, the patent holder will maximize the total rent by setting λ_m and $\bar{\lambda}$ to zero (in order to have the most flexibility in setting the consumer license fees) and setting λ_ϕ such that the price of the good equals the maximum price each consumer is willing to pay, i.e., the reservation price, net of the unit cost of production, γ . For the consumer of type ϕ , the reservation price equals $p_\phi = h\phi$ and so, the license fee equals $\lambda_\phi = h\phi - \gamma$. Provided that the patent holder is willing to bring λ_ϕ down to almost zero for consumers who are only willing to pay slightly more than the unit cost of production γ , the patent holder's overall rent from consumer licensing is given by:

$$R_c = L \int_{\frac{\gamma}{h}}^{\Phi} \left[\frac{\lambda_\phi}{\Phi} \right] d\phi = L \int_{\frac{\gamma}{h}}^{\Phi} \left[\frac{h\phi - \gamma}{\Phi} \right] d\phi = \frac{1}{2h} \frac{L}{\Phi} (h\Phi - \gamma)^2. \quad (9)$$

In Stage III, the price charged by the manufacturer to consumers is $p = \gamma$.

Non-zero transaction costs in licensing

Assume now that the patent owner incurs a transaction cost of t per unit of component x when licensing to consumers.¹⁵ Let ϕ^* denote the marginal consumer type which maximizes the patent holder's rent from consumer licensing. In Stage II, the patent holder will set the consumer license fee (net of transaction costs) equal to $\lambda_\phi = h\phi - \gamma - t$ per unit of the good sold to consumers with type $\phi \in [\phi^*, \Phi]$, while consumers with type $\phi \in [\gamma/h, \phi^*)$ will not be served. The patent holder's overall rent from consumer licensing will thus be given by:

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

¹⁵In the event the patent owner licenses to the intermediary-consumers which in turn serve the end-consumers, the unit transaction cost of licensing may vary depending upon the type of intermediary. For simplicity, we assume here that the transaction cost is the same per unit of the component, but we relax this assumption in Section 5.2, where we assume that intermediaries are heterogeneous in that they represent consumers of distinctly different willingness to pay for the final product.

Differentiating R_c with respect to ϕ^* and setting the derivative to zero, we find the optimal ϕ^* :¹⁶

$$\phi^* = \frac{1}{h}(\gamma + t). \quad (11)$$

Consumers with type $\phi \in [(\gamma + t)/h, \Phi]$, who are willing to pay more than $\gamma + t$, will be charged the price of $p_\phi = h\phi$, or, equivalently, a price of γ paid to the manufacturer plus a licensing fee of $\lambda_\phi = h\phi - \gamma - t$ paid to the patent holder plus the transaction cost of t . Note from (11) that when $t = 0$, the marginal consumer type is $\phi^* = \gamma/h$ and so it is optimal to serve all consumers with type $\phi \in [\gamma/h, \Phi]$. Substituting $\phi^* = (\gamma + t)/h$ into equation (10), we find the patent holder's overall rent from licensing to individual consumers:

$$R_c = \frac{1}{2h} \frac{L}{\Phi} (h\Phi - \gamma - t)^2. \quad (12)$$

Again, in Stage III, the manufacturer sets the price of $p = \gamma$.

3.3 Regime (2) and Regime (3) - Opt-Out

In Regime (2), the default rule is exhaustion but the patent holder may opt out by imposing downstream contractual restrictions. Conversely, in Regime (3), the default rule is no exhaustion but the patent owner may opt out by choosing not to impose downstream restrictions. In either case, the patent owner is now effectively left with a choice between Regime (1) and Regime (4), or some combination of the two (e.g., by setting a manufacturer license fee and consumer-specific license fees). For ease of exposition, we assume that the cost of opting out is low enough that Regime (2) and Regime (3) are equivalent. Indeed, no court has ever adopted Regime (3). As such, we refer to both regimes as Regime (2).

Zero transaction costs in licensing

When there are no transaction costs, in Stage II, the patent holder will always choose no exhaustion in Regime (2), since this allows the patent holder to engage in perfect price discrimination and in doing so, earn maximum rent. The comparison of (8) and (9) shows that $R_c > R_m$. That is, when transaction costs are zero, the patent holder's overall rent from consumer-specific license fees in Regime (4) exceeds that from a lump-sum manufacturer license fee in Regime (1). In Stage III, the manufacturer sets the price of $p = \gamma$.

Non-zero transaction costs in licensing

Assume now that the patent owner incurs a transaction cost of t per unit of component x when licensing to consumers, and does not incur a transaction cost when licensing to the manufacturer. In this case, in Stage II, the patent holder is left with a choice between setting consumer-specific license fees, a manufacturer license fee, or some combination of the two. For simplicity, we refer

¹⁶This result is very intuitive. This is perfect price discrimination and so, the threshold ϕ^* is simply the value of ϕ that yields zero rent (i.e., $\lambda_{\phi^*} = 0$) to the patent holder.

to Regime (1) as *pure manufacturer-licensing* and Regime (4) as *pure consumer-licensing*, and we refer to a scenario where both types of licensing occur as *mixed licensing*. Under pure consumer-licensing, the patent owner can capture the entire total surplus but must internalize the additional transaction cost. Under pure manufacturer-licensing, the patent owner saves in transaction costs but fails to capture the entire total surplus via the manufacturer, since the manufacturer must set a uniform price for all consumers as it cannot price-discriminate (on behalf of the patent holder) without incurring the transaction costs t .

If there are positive but not excessive transaction costs, the patent holder will always engage in mixed-licensing, setting consumer-specific licensing fees for consumers with high willingness to pay and a manufacturer-licensing fee for consumers with low willingness to pay.¹⁷ Such market segmentation will arise because consumer licensing is relatively more costly: the unit cost of a good under consumer licensing exceeds that under manufacturer licensing by t . The additional cost in consumer licensing makes serving low-valuation consumers via consumer-specific license fees unprofitable and the patent holder serves these displaced consumers by setting a license fee via the manufacturer.¹⁸

Let ϕ^* denote the marginal consumer type that maximizes the patent holder's overall rent under the mixed-licensing scheme. In Stage II, the patent holder will set the consumer-license fee (net of transaction cost) equal to $\lambda_\phi = h\phi - \gamma - t$ per unit of the good sold to consumers with type $\phi \in [\phi^*, \Phi]$. Consumers with type $\phi \in [p/h, \phi^*)$ will be served under the manufacturer-licensing scheme (the license fee of λ_m per unit of x plus a lump-sum fee of $\bar{\lambda}$) via a sub-license, for which transaction costs are negligible.

The number of consumers served under manufacturer licensing is given by:

$$q = L \int_{\frac{p}{h}}^{\phi^*} \left[\frac{1}{\Phi} \right] d\phi = \frac{L}{\Phi} \left[\phi^* - \frac{p}{h} \right], \quad (13)$$

where p is the price set by the manufacturer in Stage III. Thus, (3), (4), and (5) now change to:

$$p = \frac{1}{2}(h\phi^* + \lambda_m + \gamma). \quad (14)$$

$$q = \frac{1}{2h} \frac{L}{\Phi} (h\phi^* - \lambda_m - \gamma). \quad (15)$$

¹⁷Such mixed-licensing is common in many industries, as it allows the patent holder to extract some value immediately downstream, and then further value from high-valuation users for which transaction costs are relatively unimportant.

¹⁸All parties know which consumers are high-valuation and which are low-valuation and thus, there is no transaction cost in determining which consumer falls into which group. Additionally, we assume that once identified, it is relatively costless for the manufacturer to insert a simple sublicensing clause into its form agreement—with both intermediaries and end-consumers—so as to provide downstream rights to the consumers with low willingness to pay. Given a small amount of consumer surplus available to these consumers, we assume that both the manufacturer and consumer (or its intermediary) forgo negotiation over the sublicense clause, keeping transaction costs at effectively zero. We introduce information asymmetry (namely, that the patent owner may not be fully aware of the demand curve of end-consumers) in Section 5.3.

$$R_m = \lambda_m q + \Pi = \frac{1}{4h} \frac{L}{\Phi} \left[(h\phi^* - \gamma)^2 - \lambda_m^2 \right]. \quad (16)$$

Differentiating R_m with respect to λ_m and setting the derivative to zero, we find that the optimal manufacturer per-unit licensing fee set by the patent holder in Stage II is $\lambda_m = 0$, and as in Regime (1), the patent holder extracts all of its rent from the manufacturer as a lump sum.

Next, we find the marginal consumer type ϕ^* that maximizes the patent holder's total rent under the mixed-licensing scheme. This total rent equals $R_T \equiv R_m + R_c$, where

$$R_m = \frac{1}{4h} \frac{L}{\Phi} (h\phi^* - \gamma)^2 \quad (17)$$

is the patent holder's rent extracted from the manufacturer when $\lambda_m = 0$ and

$$R_c = L \int_{\phi^*}^{\Phi} \left[\frac{\lambda_{\phi}}{\Phi} \right] d\phi = L \int_{\phi^*}^{\Phi} \left[\frac{h\phi - \gamma - t}{\Phi} \right] d\phi = \frac{1}{2} \frac{L}{\Phi} (\Phi - \phi^*) \left[h(\Phi + \phi^*) - 2(\gamma + t) \right] \quad (18)$$

is the patent holder's overall rent from consumer licensing.

Differentiating R_T with respect to ϕ^* and setting the derivative to zero, we find the optimal ϕ^* :¹⁹

$$\phi^* = \frac{1}{h}(\gamma + 2t). \quad (19)$$

For this to be an interior solution, we need to impose the constraint $\phi^* < \Phi$, which is equivalent to $t < (h\Phi - \gamma)/2$. In other words, the transaction cost cannot be too large. Otherwise, there will be manufacturer licensing for all consumers.

Note that the optimal marginal consumer type under the mixed-licensing scheme, given by (19), exceeds the optimal marginal consumer type under the pure consumer-licensing scheme, which is given by (11). This implies that the patent holder will negotiate a license with fewer consumers (i.e., a narrower range of consumer types) when the exhaustion regime also allows for manufacturer sublicensing of consumers.

Consumers with type $\phi \in [(\gamma + 2t)/h, \Phi]$ will be served under a consumer-licensing scheme and will be charged the price of $p_{\phi} = h\phi$, or, equivalently, a price of γ paid to the manufacturer plus a license fee of $\lambda_{\phi} = h\phi - \gamma - t$ paid to the patent holder plus the transaction cost of t . Consumers with type $\phi \in [(\gamma + t)/h, (\gamma + 2t)/h]$ will be served under a manufacturer-licensing scheme. These low-valuation consumers will be charged the price of $p = \gamma + t$ and will purchase $q = tL/[h\Phi]$ units of the good, which follows from (14) and (15) when $\lambda_m = 0$ and $\phi^* = (\gamma + 2t)/h$.²⁰

¹⁹ $dR_T/d\phi^* = -hL/(2\Phi) < 0$. Therefore, the second order condition is satisfied as well.

²⁰We assume that at Stage II the patent owner sets ϕ^* , $\bar{\lambda}$, λ_m (which is equal to zero in equilibrium), as well as zero licensing fee for consumers of type below ϕ^* , and licensing fee of $\lambda_{\phi} = h\phi - \gamma - t$ for consumers of type above ϕ^* . Thus, in equilibrium, at Stage III, the manufacturing would charge a price of $\gamma + t$ for consumer type below ϕ^* and a price of γ for consumer type above ϕ^* .

Substituting $\phi^* = (\gamma + 2t)/h$ into (17) and (18), we further find that

$$R_m = \Pi = \frac{t^2 L}{h \Phi} = \bar{\lambda}; \quad (20)$$

$$R_c = \frac{1}{2h} \frac{L}{\Phi} (h\Phi - \gamma - 2t)(h\Phi - \gamma); \quad (21)$$

and so the patent holder's total rent is given by

$$R_T = \frac{t^2 L}{h \Phi} + \frac{1}{2h} \frac{L}{\Phi} (h\Phi - \gamma - 2t)(h\Phi - \gamma). \quad (22)$$

4 Welfare Analysis

It is apparent from Sections 3.2 and 3.3 that under reasonable assumptions, Regime (2) of opt-out exhaustion is either equivalent or superior to Regime (4) of absolute no exhaustion. Specifically, if the cost of opting out in Regime (2) is low and the patent holder-manufacturer transaction costs in licensing are relatively low, then Regime (2) is superior to Regime (4) when licensing to consumers is costly for the patent holder. First, consumer surplus is higher in Regime (2). This is because in Regime (2), consumers sublicensed by the manufacturer enjoy consumer surplus; while in Regime (4), manufacturer sublicensing of consumers is not allowed and so, no consumer enjoys consumer surplus. Second, the patent holder's total rent is higher in Regime (2). This is apparent from (12) and (22). When licensing to consumers is costless for the patent holder, Regime (2) and Regime (4) are equivalent because the patent holder will engage in pure consumer licensing in both regimes. As noted in Section 2, no court has ever adopted a regime of absolute no exhaustion.

Below we compare the social welfare among Regime (1) of absolute exhaustion and Regime (2) of opt-out exhaustion. For simplicity, we term Regime (1) as “exhaustion,” or “Regime E,” and Regime (2) as “no exhaustion,” or “Regime NE,” with the understanding that the patent holder in Regime (2) may always elect to forgo a direct license with downstream consumers by authorizing the manufacturer to provide a sublicense to some or all consumers.

4.1 Regime (1) or “Regime E”

In Regime E, the patent holder sets a lump-sum royalty fee to extract all of the producer surplus from the manufacturer, which equals:

$$PS^E = \frac{1}{4h} \frac{L}{\Phi} (h\Phi - \gamma)^2. \quad (23)$$

The manufacturer sets the price of $p^E = (h\Phi + \gamma)/2$. A consumer of a type $\phi > p^E/h$ purchases one unit of good y and earns utility of $h\phi - p^E$, while a consumer of a type $\phi < p^E/h$ does not

purchase good y and earns the utility of zero. Thus, the consumer surplus is given by:

$$CS^E = L \int_{\frac{p^E}{h}}^{\Phi} \left[\frac{h\phi - p^E}{\Phi} \right] d\phi = \frac{1}{2h} \frac{L}{\Phi} (h\Phi - p^E)^2 = \frac{1}{8h} \frac{L}{\Phi} (h\Phi - \gamma)^2. \quad (24)$$

The manufacturer pricing leads to a deadweight loss in the amount of $DWL^E = S - CS^E - PS^E$, where S is the maximum potential surplus. The deadweight loss would not arise if the patent holder could perfectly price discriminate. In that case, the patent holder would set the consumer-specific license fee of $h\phi - \gamma$ and with this fee, extract all consumer surplus from consumers with $\phi > \gamma/h$, who would purchase one unit of good y . The patent holder's rent (i.e., the producer surplus) would then equal the maximum potential surplus (i.e., the total surplus), given by:

$$S = L \int_{\frac{\gamma}{h}}^{\Phi} \left[\frac{h\phi - \gamma}{\Phi} \right] d\phi = \frac{1}{2h} \frac{L}{\Phi} (h\Phi - \gamma)^2. \quad (25)$$

Using (23), (24) and (25), we find the deadweight loss:

$$DWL^E = L \int_{\frac{\gamma}{h}}^{\frac{p^E}{h}} \left[\frac{p^E - h\phi}{\Phi} \right] d\phi = \frac{1}{8h} \frac{L}{\Phi} (h\Phi - \gamma)^2. \quad (26)$$

Figure 1 plots the linear demand function $q(p)$ given by (1) and shows the composition of $S = PS^E + CS^E + DWL^E$. At the price of p^E , the quantity demanded is q^E , which equals the number of consumers who purchase good y . Given that the unit cost of producing y is γ , and since the patent holder extracts all profit from the manufacturer with the lump-sum license fee, the patent holder's rent is $PS^E = (p^E - \gamma)q^E$. Consumers who are willing to pay more than p^E earn consumer surplus of $CS^E = 0.5(h\Phi - p^E)q^E$. Consumers who are willing to pay less than p^E but more than γ are not served. Since q_0 units of y would have been demanded at the price of γ , the resulting deadweight loss is $DWL^E = 0.5(p^E - \gamma)(q_0 - q^E)$.

4.2 Regime (2) or “Regime NE”

In Regime NE, when the transaction costs are positive but not too large, the patent holder allows sublicensing to low-valuation consumers via a manufacture but requires direct licenses from high-valuation consumers. From equation (22), the producer surplus under Regime NE is given by:

$$PS^{NE} = \frac{t^2}{h} \frac{L}{\Phi} + \frac{1}{2h} \frac{L}{\Phi} (h\Phi - \gamma - 2t)(h\Phi - \gamma). \quad (27)$$

Consumers of type $\phi \in [\phi^*, \Phi]$ pay the consumer-specific price which equals their reservation price and earn no consumer surplus, but consumers of type $\phi \in (p/h, \phi^*)$, who are sublicensed by the

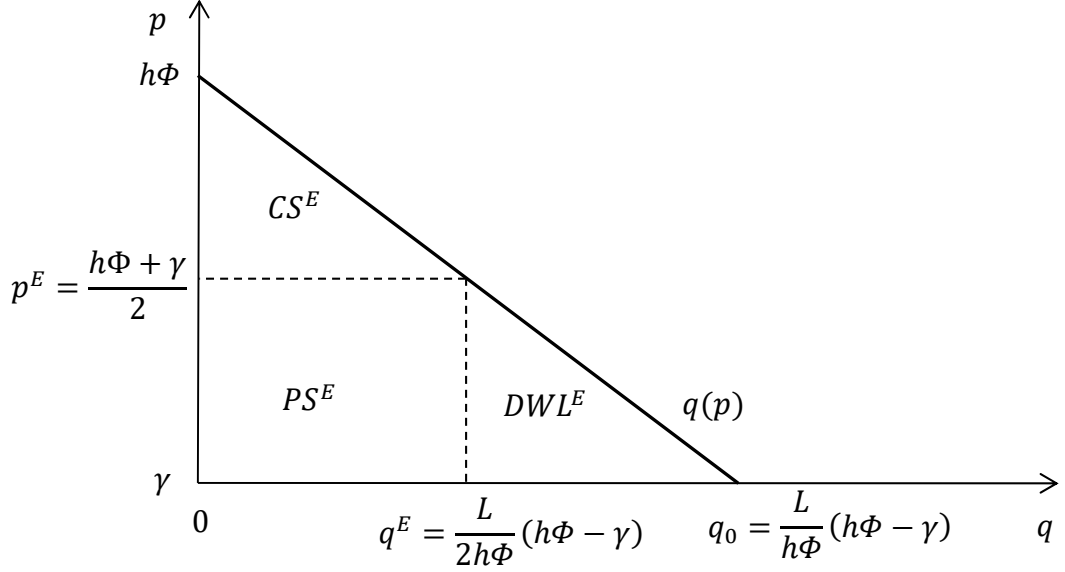


Figure 1: **Regime E**

manufacturer, pay the price of $p^{NE} = \gamma + t$ and will enjoy consumer surplus of:

$$CS^{NE} = L \int_{\frac{p^{NE}}{h}}^{\phi^*} \left[\frac{h\phi - p^{NE}}{\Phi} \right] d\phi = \frac{t^2}{2h} \frac{L}{\Phi}. \quad (28)$$

As in Regime E, there is deadweight loss—here, from (i) positive transaction costs of directly licensing consumers; and (ii) the inability to price discriminate when the manufacturer sublicenses. The maximum potential surplus S in an ideal regime of perfect price discrimination with zero transaction costs in licensing is given by (25). Thus, the deadweight loss is as follows:

$$DWL^{NE} = S - CS^{NE} - PS^{NE} = \frac{t}{2h} \frac{L}{\Phi} \left[2(h\Phi - \gamma) - 3t \right]. \quad (29)$$

Figure 2 shows the composition of $S = CS^{NE} + PS^{NE} + DWL^{NE}$. The market has two segments: (i) low-valuation consumers served under the manufacturer-licensing scheme and (ii) high-valuation consumers served under the consumer-licensing scheme. For low-valuation consumers, the demand is given by $q^L \equiv q(p; \phi^*)$ in (13). For high-valuation consumers with $\phi \in [\phi^*, \Phi]$, the willingness to pay is given by $h\phi$, and 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 in (1).

Consider first the consumer-licensing scheme. High-valuation consumers with $\phi > \phi^* = (\gamma + 2t)/h$ will purchase $q_{\phi^*} = \frac{L}{h\Phi}(h\Phi - h\phi^*) = \frac{L}{h\Phi}(h\Phi - \gamma - 2t)$ units of y under perfect price discrimination. The patent holder will extract all consumer surplus from these consumers and earn the overall rent from this market segment in the amount of $\tilde{R}_c = 0.5(h\Phi - h\phi^*)q_{\phi^*}$ plus $\lambda_{\phi^*}q_{\phi^*} = (h\phi^* - \gamma - t)q_{\phi^*} = tq_{\phi^*}$, which equals R_c in (21). Now consider the manufacturer-licensing scheme. At the price of p^{NE} ,

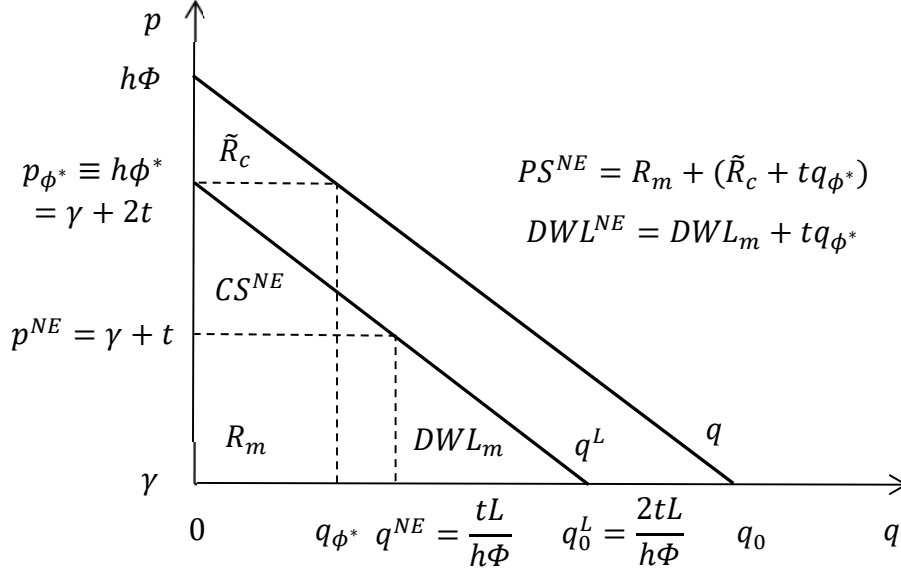


Figure 2: **Regime NE**

the quantity demanded equals q^{NE} . The patent holder extracts all profit from the manufacturer, which amounts to $R_m = (p^{NE} - \gamma)q^{NE}$. Low-valuation consumers who are willing to pay less than $p_{\phi^*} \equiv h\phi^*$ but more than p^{NE} will earn $CS^{NE} = 0.5(p_{\phi^*} - p^{NE})q^{NE}$ in consumer surplus; while those who are willing to pay less than p^{NE} will not be served, resulting in the deadweight loss of $DWL_m = 0.5(p^{NE} - \gamma)(q_0^L - q^{NE})$. The aggregate deadweight loss in Regime NE is $DWL^{NE} = DWL_m + tq_{\phi^*}$, where tq_{ϕ^*} is the total amount of transaction costs. In Figure 2, DWL^{NE} is the area of the trapezoid with base $q_0 - q^{NE}$ and height $p^{NE} - \gamma$.

4.3 Comparison of the Regimes

When the transaction cost is too high (i.e., $t \geq (h\Phi - \gamma)/2$), the marginal consumer type equals the highest consumer type (i.e., $\phi^* = \Phi$) and so, the system collapses to pure manufacturer-licensing: $q^E = q^{NE}$ and $p^E = p^{NE}$. Thus in what follows, we assume that $t < (h\Phi - \gamma)/2$ so that $\phi^* < \Phi$.

First, it is instructive to evaluate how the equilibrium prices and quantities compare across the two regimes. Proposition 1 establishes the result.

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

Proposition 1 states that the price and quantity under the manufacturer-licensing scheme are higher in Regime E compared to Regime NE: $q^E > q^{NE}$ and $p^E > p^{NE}$. It is ambiguous how the quantity under the manufacturer-licensing scheme in Regime E compares to the quantity under the consumer-licensing scheme in Regime NE. This comparison depends on the value of t , as

summarized in Proposition 1, with the two possible cases illustrated in Figure 3.

We now evaluate how the producer surplus (i.e., the patent holder's overall rent) and consumer surplus compare across Regime E and Regime NE. Proposition 2 follows.

Proposition 2 $PS^{NE} > PS^E$ and $CS^{NE} < CS^E$.

Proof: It follows from (23)-(24) and (27)-(28) that:

$$PS^{NE} - PS^E = \frac{1}{4h} \frac{L}{\Phi} (h\Phi - \gamma - 2t)^2 > 0 \quad \text{and} \quad CS^{NE} - CS^E = \frac{1}{8h} \frac{L}{\Phi} \left[4t^2 - (h\Phi - \gamma)^2 \right] < 0.$$

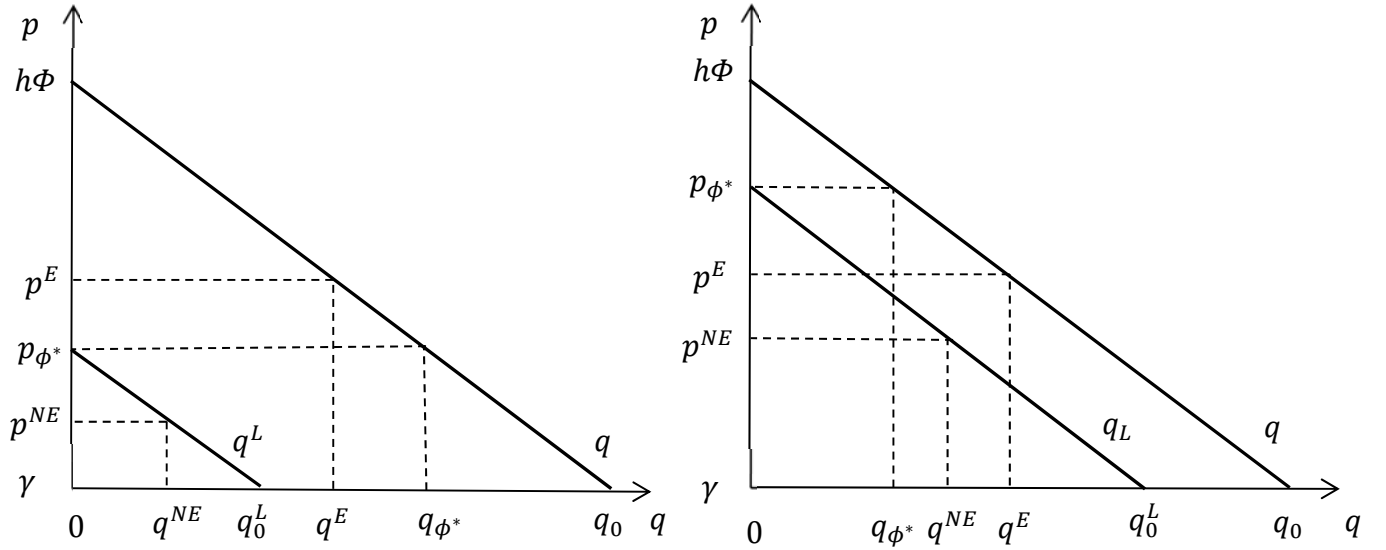


Figure 3: **Price and quantity comparison.** Case (i) at left and case (ii) at right

When transaction costs are zero, the patent holder's overall rent under Regime NE, PS^{NE} , equals the overall rent under the pure consumer-licensing scheme, R_c in (9). The consumer-licensing scheme is most profitable when $t = 0$ because it allows the patent holder to extract the full consumer surplus from every paying consumer while incurring no transaction cost. This merely confirms the standard proposition that price discrimination in the context of patent licensing is optimal in the absence of transaction costs.

When transacting with consumers is costly ($t > 0$), the mixed-licensing scheme under Regime NE ensures greater overall rent to the patent holder compared to the pure manufacturer licensing scheme under Regime E. This result is intuitive, as the patent holder has more options open to it under Regime NE than under Regime E.

Figure 4 shows how CS^E compares to CS^{NE} , with the low- t case (i) on the left and the high- t case (ii) on the right.²¹ Consumer surplus is realized in both regimes, but it is relatively low in

²¹Refer to Proposition 1 for the exact definition of these two cases.

Regime NE. There are two reasons for this result. First, the number of consumers purchasing good y under the manufacturer-licensing scheme is relatively low in Regime NE: $q^{NE} < q^E$. Second, the difference between the maximum consumer valuation and the price is relatively low in Regime NE: $p_{\phi^*} - p^{NE} < h\Phi - p^E$. The result that $CS^{NE} < CS^E$ is intuitive as under Regime NE, only low-valuation consumers (who receive a sublicense from the manufacturer) earn consumer surplus, while high-valuation consumers (who are subject to price discrimination by the patent holder) lose all their consumer surplus. Under Regime E, by contrast, all consumers are charged one single monopoly price by the manufacturer (to prevent arbitrage), and so a larger set of consumers earn consumer surplus. Note that the interests of high-valuation and low-valuation consumers are conflicting: high-valuation consumers always prefer Regime E to Regime NE, while the opposite is true for low-valuation consumers.

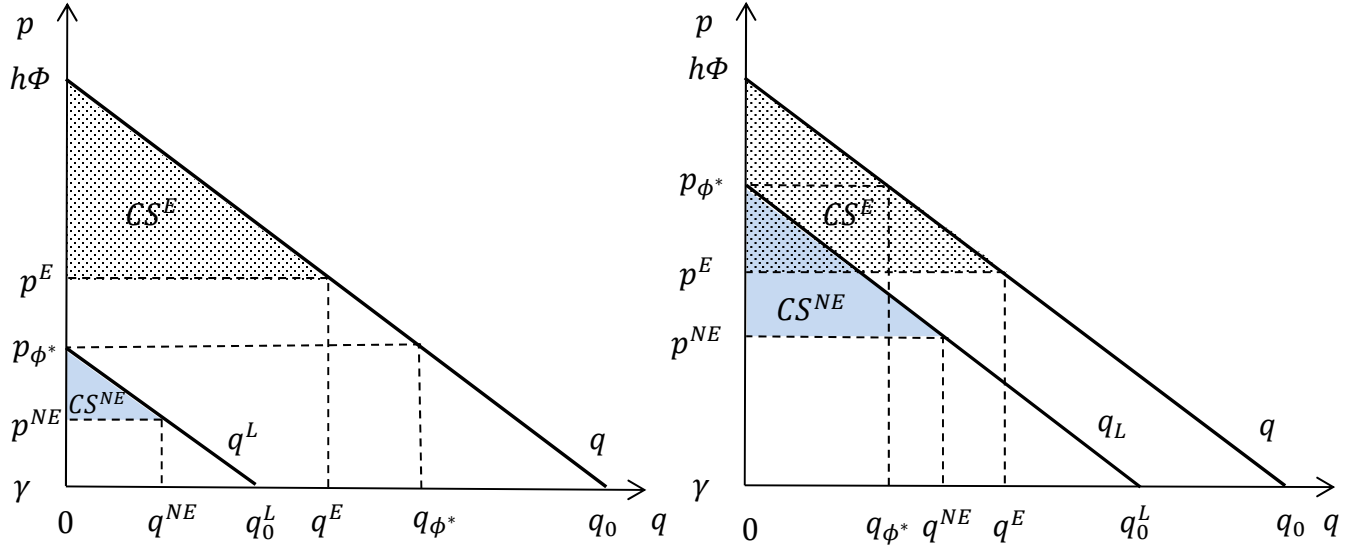


Figure 4: **Comparison of CS. Case (i) at left and case (ii) at right**

Last, we compare the deadweight loss across the two regimes. This comparison is given by:

$$DWL^{NE} - DWL^E = [S - PS^{NE} - CS^{NE}] - [S - CS^E - PS^E] = [CS^E + PS^E] - [PS^{NE} + CS^{NE}].$$

Proposition 3 establishes the result.

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

Proof: From (26) and (29), we obtain:

$$DWL^{NE} - DWL^E = \frac{1}{8h} \frac{L}{\Phi} \left[-12t^2 + 8t(h\Phi - \gamma) - (h\Phi - \gamma)^2 \right],$$

which is zero when $t = (h\Phi - \gamma)/6$ or $t = (h\Phi - \gamma)/2$; negative when $0 \leq t < (h\Phi - \gamma)/6$; and positive when $(h\Phi - \gamma)/6 < t < (h\Phi - \gamma)/2$.

Deadweight loss is relatively low in Regime NE when the transaction cost is low. This is for two reasons. First when t is low, the patent holder serves a large number of high-valuation consumers under the consumer-licensing scheme (which does not lead to a loss of economic efficiency) in Regime NE, whereas it cannot require direct licenses from the consumers in Regime E. Second when t is low, the total amount of transaction costs (which adds to the deadweight loss) is low. As the transaction cost t rises, the number of consumers who license directly from the patent holder in Regime NE greatly diminishes, while the total amount of transaction costs rises. Consequently, deadweight loss is relatively low in Regime E when the transaction cost is high.

Figure 5 shows how DWL^E compares to DWL^{NE} , with the low- t case (i) on the left and the high- t case (ii) on the right. DWL^{NE} is the area of the trapezoid with base $q_0 - q^{NE}$ and height $p^{NE} - \gamma$, while DWL^E is the area of the triangle with base $q_0 - q^E$ and height $p^E - \gamma$. On the left, where t is small, the number of consumers who license directly from the patent holder in Regime NE is large and thus, $DWL^{NE} < DWL^E$. On the right, where t is large, the number of consumers who license directly from the patent holder in Regime NE is small and thus, $DWL^{NE} > DWL^E$.

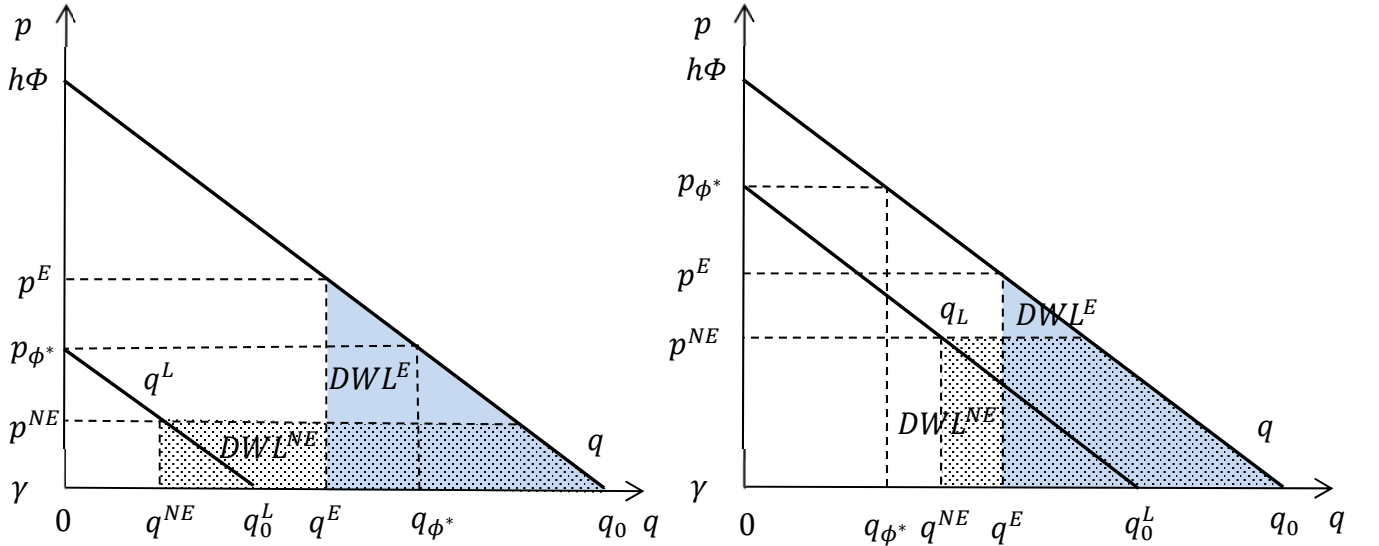


Figure 5: **Comparison of DWL. Case (i) at left and case (ii) at right**

From the social welfare point of view, we find that Regime NE is socially optimal—in static terms—when transaction costs are low. This is because when t is small, the gain in producer surplus in Regime NE (relative to Regime E) more than offsets the loss in consumer surplus. As t rises, however, the relative gain in producer surplus falls rapidly; while the relative loss in consumer surplus also falls, but slowly. Consequently, when t is large, the total surplus in Regime NE is below that in Regime E. This is shown in Figure 6. On the left, CS^{NE} rises slowly while PS^{NE} falls fast as t rises from zero; and CS^E and PS^E do not vary with t . On the right, the sum of CS^{NE} and PS^{NE} is above $CS^E + PS^E$ at $t = 0$ but it declines as t rises from zero, falling below $CS^E + PS^E$ when $(h\Phi - \gamma)/6 < t < (h\Phi - \gamma)/2$.

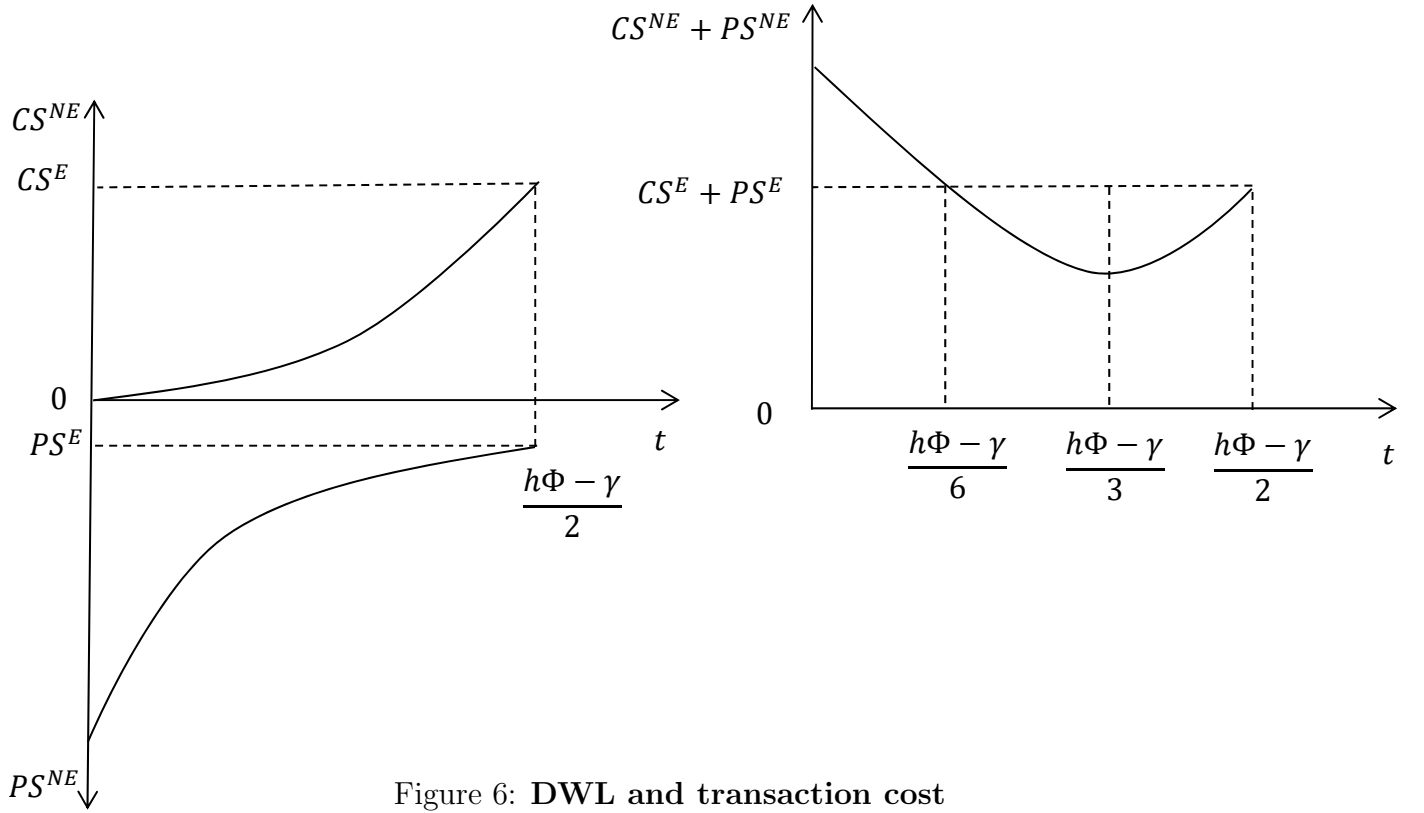


Figure 6: **DWL and transaction cost**

5 Extensions

In Section 3, we made several simplifying assumptions that could affect the welfare analysis. Here, we discuss how our results may change when those assumptions are relaxed. First, in Section 5.1, we examine how the patent holder's incentive to invest in product quality—which is a proxy for the effect on overall inventive activity—in the regime of absolute exhaustion (Regime E) compares with that in the regime of opt-out exhaustion (Regime NE). We show that dynamic efficiency rises in Regime NE, and these dynamic gains in promoting *ex ante* investment in product quality may outweigh any loss of static efficiency in Regime NE when transaction costs are high.

Second, in Section 5.2, we assume that there exist intermediaries that purchase and license on behalf of the end-consumers, and we also relax the assumption of zero transaction costs between the patent holder and the manufacturer. Our results do not change qualitatively. In fact, it is more likely that Regime NE is more efficient than Regime E when each intermediary negotiates the license fees on behalf of a large number of consumers, as it saves the transaction cost per consumer.

Third, in Section 5.3, we introduce information asymmetry—namely, that the patent owner may not be fully aware of the demand curve of end-consumers. This is particularly the case when the patented good is a mere component of a complex product, and it is difficult to estimate the overall value of the component to consumers. Alternatively, it may be difficult for the patent owner to determine if a given component would be found by a court to infringe a valid patent.

In this instance, it will be difficult for the patent owner to estimate a consumer’s willingness to pay. As such, this extension also approximates the effects of high search costs that a downstream purchaser would otherwise incur when attempting to determine if it is potentially subject to license fees to upstream patent owners. We find that asymmetric information acts like an increase in the transaction cost. Thus, it makes it more likely that Regime E would dominate Regime NE in terms of static efficiency.

Fourth, in Section 5.4, we discuss restraints on alienation. Specifically, we address the concern that if a non-patented component exists that could have been used *ex ante*, high switching costs may allow the patent owner to gain leverage over the consumer, resulting in suboptimal licensing. As an initial matter, we note that this is only a potential concern where the patent holder has some market power, otherwise the existence of the patent does not lead to results different from ordinary markets. If the patent holder does enjoy market power, absolute exhaustion could alleviate switching-cost problems, but we contend that—given the potential benefits of presumptive exhaustion—absolute exhaustion is a rather blunt instrument to achieve such a result. Rather, other doctrines (such as patent misuse and antitrust law) can remedy situations in which patents are inefficiently constraining downstream activity.

Fifth, in Section 5.5, we examine the situation when substitutes for the patented component exist. If there are perfect substitutes for the patented good that are readily available and known to potential consumers, then exhaustion is effectively irrelevant. However, if there are merely imperfect substitutes, our qualitative results still hold—namely, that when transaction costs are low, presumptive exhaustion is statically more efficient, and when transaction costs are high, absolute exhaustion is statically more efficient.

Last, in Section 5.6, we consider goods comprising multiple patented components. Here, we find that although our qualitative results continue to hold, when transaction costs are high both static and dynamic efficiency may be greater in a regime of absolute exhaustion. Thus, as the number of components in a given product that are patented increases (especially when dealing with multiple patent owners requiring separate negotiations) and transaction costs (such as search, information, and negotiation costs) are high, absolute exhaustion begins to be more attractive. This result underscores our more general result that the relative efficiency of absolute and presumptive exhaustion is likely to vary widely by industry, technology, and product.

5.1 Dynamic Effects and Quality-Feedback Mechanisms

Proposition 3 in Section 4 states that when transaction costs are sufficiently low, i.e., $0 \leq t < (h\Phi - \gamma)/6$, Regime E of absolute exhaustion results in a greater loss of static efficiency compared to Regime NE. However, when transaction costs are high, i.e., $(h\Phi - \gamma)/6 < t < (h\Phi - \gamma)/2$, Regime NE of opt-out exhaustion leads to a greater static efficiency loss. Yet, static efficiency is not the only important welfare concern. When assessing the welfare impact of a patent exhaustion regime, it is also 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—including investments in product quality—that the patent owner and manufacturer are willing to make.

Indeed, if producer surplus is too low, the patent holder may not invent at all.

As a proxy for overall *ex ante* innovation, we examine how investment in product quality h in Regime E compares to that in Regime NE. For simplicity, we assume the quality of good y is determined by the quality of the component x , which is set by the patent holder prior to setting manufacturer license fees. The optimal quality in a regime $k = \{E, NE\}$ will maximize the patent holder's net producer surplus (or rent), $PS^k(h) - H(h)$, where $H(h)$ is the cost of investing in quality such that $d^2H/dh^2 > 0$ and $d^2H(h)/dh^2 > d^2PS^k(h)/dh^2$. Differentiating PS^E and PS^{NE} , given by (23) and (27), with respect to h , we find the marginal benefit of quality under each regime:

$$\frac{dPS^E(h)}{dh} = \frac{1}{4h^2} \frac{L}{\Phi} \left[h^2 \Phi^2 - \gamma^2 \right] > 0 \quad \text{and} \quad \frac{dPS^{NE}(h)}{dh} = \frac{1}{2h^2} \frac{L}{\Phi} \left[h^2 \Phi^2 - (\gamma + t)^2 - t^2 \right] > 0.$$

The optimal quality will set the marginal benefit equal to the marginal cost. To find an explicit solution, we assume the cost of investing in quality when $h > \sqrt{a/\xi}$ is given by:²²

$$H(h) = \frac{1}{4} \left[\xi h + \frac{a}{h} \right], \quad \text{where} \quad a > \frac{\xi}{\Phi^2} \left[(\gamma + t)^2 + t^2 \right] \quad \text{and} \quad \xi > 2L\Phi. \quad (30)$$

When $H(h)$ is given by (30), the optimal quality in each regime is given by:

$$h^E = \left[\frac{\Phi a - L\gamma^2}{\Phi(\xi - L\Phi)} \right]^{1/2} \quad \text{and} \quad h^{NE} = \left[\frac{\Phi a - 2L[(\gamma + t)^2 + t^2]}{\Phi(\xi - 2L\Phi)} \right]^{1/2}.$$

It is easy to show that $h^E < h^{NE}$, since $t < (\Phi h^E - \gamma)/2$ (recall that with any higher transaction costs, Regime NE collapses to pure manufacturer licensing, so that $PS^{NE} = PS^E$).²³ This implies that the patent holder's *ex-ante* investment into product quality will rise in response to a shift in patent policy from absolute to opt-out exhaustion. That is, dynamic efficiency will rise in Regime NE. Furthermore, if the positive impact on investment into quality is strong, the gain in dynamic efficiency in Regime NE will likely offset the potential loss of static efficiency, which arises in Regime NE when transaction costs are high, and Regime NE will be socially optimal as a result.

5.2 Licensing via Heterogeneous Intermediaries and Manufacturer Transaction Costs

So far, we focused on the end-consumers, assuming that transaction costs between the patent holder and end-consumers are borne on a per-unit basis, and abstracted away from the intermediaries, such as wholesalers and resellers. This assumption is justified when the manufacturer sells directly to end-consumers, patent exhaustion is presumptive, and the patent holder opts out, because in

²²The parameter ξ is the fixed component of the marginal cost of quality and the parameter a measures the rate at which the marginal cost of quality rises as h rises. We restrict a and ξ to satisfy the conditions in (30) to ensure that maximum h^E and h^{NE} exist. To complete the characterization of $H(h)$, we assume that $H(0) = 0$ and $H(h)$ is increasing in h when $h \in [0, \sqrt{a/\xi}]$.

²³The condition $t < (\Phi h^E - \gamma)/2$ is necessary and sufficient for $h^E < h^{NE}$.

this instance, a consumer may be required to enter into a separate licensing agreement with the patent holder. It is also justified when intermediaries are relatively homogeneous, purchasing and licensing (if need be) on behalf of groups of end-consumers with similar valuation distributions of the final product. In this section, we assume that intermediaries are heterogeneous in that they represent consumers 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.

Suppose there are a number of intermediaries such that each intermediary sells to a group of N consumers. Suppose further that the first intermediary serves the N consumers with the highest valuations, and then the second intermediary serves the N consumers with the next highest valuations, and so on. Thus, intermediaries are heterogeneous, being distinguished by the average valuation of its consumers. Assume that the patent owner incurs a fixed transaction cost of t_m sublicensing consumers via the manufacturer and separate fixed transaction cost t when licensing directly to each intermediary. Suppose each intermediary can price discriminate with all of its consumers without incurring any additional transaction costs. This effectively means that the transaction cost per consumer is t/N . Under Regime NE, in the case of consumer licensing, the patent holder sublicenses the consumers through the intermediaries. In equilibrium, the patent holder would extract all the rents (consumer surplus) from the intermediary through a lump sum licensing fee. When $t_m > 0$, the optimal manufacturer-license fee is still $\lambda_m = 0$, but the lump sum royalty becomes $\bar{\lambda} = \Pi - t_m$.

In Regime E, the manufacturer profit maximizing price and quantity will be given by:

$$p^E = \frac{1}{2}(h\Phi + \gamma) \quad \text{and} \quad q^E = \frac{1}{2h}\frac{L}{\Phi}(h\Phi - \gamma);$$

and producer surplus (or the patent holder's rent, extracted from the manufacturer with a lump-sum royalty fee), consumer surplus, and the deadweight loss will be as follows:

$$PS^E = \frac{1}{4h}\frac{L}{\Phi}(h\Phi - \gamma)^2 - t_m \quad \text{and} \quad CS^E = \frac{1}{8h}\frac{L}{\Phi}(h\Phi - \gamma)^2; \quad (31)$$

$$DWL^E = \frac{1}{8h}\frac{L}{\Phi}(h\Phi - \gamma)^2 + t_m. \quad (32)$$

In other words when $t_m > 0$, the manufacturer price and sales are unchanged; and as a result, producer surplus is lower but consumer surplus is unchanged while the deadweight loss is higher.

In Regime NE, the optimal marginal consumer type and the optimal manufacturer price and quantity will be given by:²⁴

$$\phi^* = \frac{1}{h}\left(\gamma + 2\frac{t}{N}\right), \quad p^{NE} = \gamma + \frac{t}{N} \quad \text{and} \quad q^{NE} = \frac{t}{Nh}\frac{L}{\Phi}. \quad (33)$$

Consumers with type $\phi \in [(\gamma + 2\frac{t}{N})/h, \Phi]$ will be served under a consumer-licensing scheme and will be charged the price of $p_\phi = h\phi = \lambda_\phi + \gamma + \frac{t}{N}$. Consumers with type $\phi \in [(\gamma + \frac{t}{N})/h, (\gamma + 2\frac{t}{N})/h]$

²⁴We assume that $t/N < (h\Phi - \gamma)/2$ so that $\phi^* < \Phi$.

will be served under a manufacturer-licensing scheme and will be charged the price of p^{NE} and will purchase q^{NE} units of the good. The patent holder's rent under each scheme will be as follows:

$$R_m = \frac{t^2}{N^2 h} \frac{L}{\Phi} - t_m \quad \text{and} \quad R_c = \frac{1}{2h} \frac{L}{\Phi} \left(h\Phi - \gamma - 2\frac{t}{N} \right) (h\Phi - \gamma).$$

A positive t_m reduces the patent holder's rent under the manufacturer-licensing scheme, R_m , because it reduces the profit that the patent holder can extract from the manufacturer. The patent holder's rent under the consumer-licensing scheme, R_c , is unchanged when $t_m > 0$, because the number of consumers served under this scheme is unchanged. Nonetheless, the patent holder's total rent, $R_T = R_m + R_c$, falls when we introduce $t_m > 0$.

Producer surplus, consumer surplus, and the deadweight loss in Regime NE will be as follows:

$$PS^{NE} = \frac{1}{2h} \frac{L}{\Phi} \left[(h\Phi - \gamma - 2\frac{t}{N})(h\Phi - \gamma) + 2\frac{t^2}{N^2} \right] - t_m \quad \text{and} \quad CS^{NE} = \frac{1}{2h} \frac{L}{\Phi} \frac{t^2}{N^2}; \quad (34)$$

$$DWL^{NE} = \frac{1}{2h} \frac{L}{\Phi} \left[2\frac{t}{N}(h\Phi - \gamma) - 3\frac{t^2}{N^2} \right] + t_m. \quad (35)$$

Using the results in (31) and (34), it is easy to show that $PS^{NE} > PS^E$, $CS^{NE} < CS^E$, and $DWL^{NE} < DWL^E$ iff $0 \leq t/N < (h\Phi - \gamma)/6$ and $DWL^{NE} \geq DWL^E$ iff $(h\Phi - \gamma)/6 \leq t/N \leq (h\Phi - \gamma)/2$. Thus, Propositions 2 and 3 continue to hold qualitatively regardless of the magnitude of the manufacturer transaction cost, as t_m reduces PS^{NE} and PS^E by the same amount but does not affect CS^{NE} and CS^E . However, for the same value of t , it is more likely that $DWL^{NE} < DWL^E$, meaning that it is more likely that Regime NE is more efficient than Regime E when each intermediary negotiates the license fees on behalf of a large number of consumers, as it saves the transaction cost per consumer.

5.3 Information Asymmetries in Assessing Consumer Demand

We had previously assumed that all parties were omniscient, particularly regarding consumer demand. It is possible that the presence of information asymmetries exacerbates the social costs of opt-out (presumptive) exhaustion by raising overall transaction costs. Specifically, suppose the patent owner must incur a positive cost c_r to determine the willingness of the consumer to pay for the patented good, i.e., the consumer type ϕ . We assume that without paying this “revelation cost” the patent holder only knows that there are L consumers, with their willingness to pay for quality ϕ being uniformly distributed over the interval $[0, \Phi]$. In order to price discriminate under Regime NE, the patent holder must incur a total revelation cost of Lc_r .²⁵ Thus, it will price-

²⁵An alternative in Regime NE to incurring such a cost *ex ante* is for the patent owner to set a base upstream royalty amount λ_0 charged by the manufacturer plus an additional downstream royalty amount λ_ϕ^D directly to the patent owner. The base royalty acts as a costly screen, eliminating the need for the patent owner to investigate the willingness to pay of all consumers. In particular, when transaction costs in licensing are zero ($t = 0$), the manufacturer will set the price of $p = \gamma + \lambda_0$ in Stage III (but the manufacturer will end up getting zero profit as the patent owner extracts all its profits through a lump-sum royalty). High-valuation consumers with $\phi > (\gamma + \lambda_0)/h$

discriminate iff $PS^{NE} - PS^E > Lc_r$, where $PS^{NE} - PS^E = \frac{1}{4h} \frac{L}{\Phi} (h\Phi - \gamma - 2t)^2$ from Section 4.3. In other words, Regime NE collapses to Regime E at a lower t than before. The threshold t solves $\frac{1}{4h} \frac{L}{\Phi} (h\Phi - \gamma - 2t^*)^2 = Lc_r$ and is given by

$$t^* = \frac{1}{2}(h\Phi - \gamma) - \sqrt{h\Phi c_r}.$$

If $t > t^*$, the patent holder will adopt pure manufacturer licensing.²⁶ On the other hand, when $t < t^*$, the patent holder will price-discriminate and producer surplus PS^{NE} will be given by (27) minus Lc_r , while consumer surplus CS^{NE} will remain the same, as in (28). Diagrammatically, the curve $CS^{NE} + PS^{NE}$ on the right panel of Figure 6 is shifted down by an amount Lc_r for $t < t^*$, and it becomes the same as the curve $CS^E + PS^E$ for $t > t^*$. If c_r is sufficiently small that $CS^{NE} + PS^{NE}$ at $t = 0$ is greater than $CS^E + PS^E$,²⁷ it would continue to be the case that Regime NE is more efficient than Regime E when t is small, and Regime E is more efficient than Regime NE when t is large. In fact, Propositions 2 and 3 would continue to hold qualitatively. However, if c_r is so large that $CS^{NE} + PS^{NE}$ at $t = 0$ is smaller than $CS^E + PS^E$, then Regime E is always more efficient than Regime NE.

Thus, the more serious is the asymmetric information problem concerning consumers' willingness to pay, the more likely it is that Regime E dominates Regime NE in terms of static efficiency, as it makes it harder for the patent holder to price discriminate between consumers. In this sense, asymmetric information acts like an increased transaction cost. A similar information asymmetry arises when a consumer has difficulty determining whether a product it is considering purchasing from a downstream seller is potentially covered by patents owned by upstream patent holders. Given this uncertainty, the consumer does not know the price it would be willing to pay to license any such patents, which in turn effects the fully loaded price the consumer must pay for the product. In order to better determine whether it wants to purchase the product, the consumer may incur a cost to do a patent search to identify any patents covering the product, after which, the consumer may contact the patent holders (if any exist) and negotiate licensing fees. Such a circumstance is roughly equivalent to lack of knowledge on the part of the patent holder about a potential buyer's willingness to pay, because the patent holder could always incur some positive cost to reveal to a potential downstream consumer that the product is covered by a patent, and then negotiate a licensing fee. Assuming the cost of the upstream patent owner to identify and contact a potential downstream consumer is roughly the same as the cost for the consumer to discover the same information and contact the patent holder, then our analysis above implies that

will purchase the good at this price and are thus easily identifiable. The total number of these consumers is $\frac{L}{\Phi} [\Phi - \frac{\gamma + \lambda_0}{h}]$ and so, the total patent holder's revelation cost is only $c_r \frac{L}{\Phi} [\Phi - \frac{\gamma + \lambda_0}{h}]$. The patent holder will then set $\lambda_\phi^D = h\phi - \gamma - \lambda_0$ to extract all consumer surplus. The total patent holder's rent will be equal to $PS = \frac{1}{2h} \frac{L}{\Phi} (h\Phi - \gamma - \lambda_0)^2 + \frac{1}{h} \frac{L}{\Phi} (\lambda_0 - c_r)(h\Phi - \gamma - \lambda_0)$, where the first term is the amount of extracted consumer surplus and the second term is the total base rent net of revelation cost. It is easy to show that the optimal base royalty is $\lambda_0^* = c_r$. At this base royalty, the patent holder's overall rent is $PS = \frac{1}{2h} \frac{L}{\Phi} (h\Phi - \gamma - c_r)^2$. Note that PS equals the right hand side of (12) when $c_r = t$, which implies that the revelation cost of determining consumer demand *ex post* acts like a transaction cost under absolute no exhaustion, where the patent owner is required to negotiate the licensing fee with all customers who buy the good.

²⁶If c_r is too large, the patent holder will adopt pure manufacturer licensing even if the transaction cost is zero.

²⁷The condition for this to be true is $c_r < \frac{1}{8h\Phi} (h\Phi - \gamma)^2$.

a higher patent search cost for the consumer acts like a higher transaction cost t in our basic model. Specifically, if search costs are high (i.e., information asymmetry is more prominent), then absolute exhaustion may be preferable to presumptive exhaustion.²⁸

5.4 Consumer Switching Costs

Perzanowski and Schultz (2011) assert that contractual limitations on downstream users can exacerbate switching costs by “locking in” consumers to certain types of technology. For example, in the *LG v. Quanta* case discussed earlier, the license at-issue prevented purchasers of the patented components from combining those goods with products made by parties other than those from the initial licensee, Intel. Thus, the downstream license was a classic case of tying a patented good to an unpatented one. Indeed, many of the judicial opinions addressing patent exhaustion and related doctrines arise in the context of downstream tying restrictions. For instance, 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.

In the event the patent provides the patent holder with *no* market power (i.e., there are reasonable substitutes for the patented component), tying cannot present an economic concern—at least in static equilibrium—because buyers will simply demand lower prices for the patented good in exchange for being forced to purchase the unpatented good. In dynamic equilibrium, especially in the event the patent does provide market power, it could be argued that tying may be welfare-reducing (Choi and Stefandis, 2001; Nalebuff, 2004). However, even if there are such effects, it is unclear why such a blunt instrument as absolute exhaustion, which precludes all downstream limitations, is necessary to remedy these concerns. Rather, courts have been deciding ordinary antitrust cases for a century, and have applied the related patent misuse doctrine for longer still. If tying is a concern, the courts can address it directly using these and related doctrines (Zheng, 2016). Adopting absolute exhaustion, to use a cliché, is akin to throwing the baby (of price discrimination) out with the bathwater (of anti-competitive behavior). When the bathwater is perfectly clean (i.e., there is no anti-competitive behavior), downstream restrictions that afford price discrimination can be welfare-enhancing in the presence of low transaction costs. Thus, easing consumer switching costs—while potentially a welfare-increasing result of absolute exhaustion in certain circumstances—does not alter our findings across the variety of transactions engaged in by

²⁸Another type of information asymmetry involves uninformed individual consumers unknowingly agreeing to downstream limitations on the use of purchased goods. Here, the notion is that if consumers are unaware of such limitations—and it is very costly to become aware of and negotiate the limitations—upstream licensors can impose socially harmful terms on consumers to extract rents that consumers otherwise would bargain away barring the transaction costs of curing the information asymmetry. Absolute exhaustion can help solve these market defects by making the limitations effectively unenforceable in patent actions. However, it is unclear to us why a broad-brush doctrine like exhaustion is necessary in these situations when other equitable doctrines (such as patent misuse or contract law principles like unconscionability) can be used to render these terms unenforceable. In view of these solutions, and assuming that most relevant licensing transactions in patent law occur between sophisticated parties, we think such asymmetries are unlikely to justify absolute exhaustion on economic grounds.

patent owners.

5.5 Substitutes for the Patented Component

In our model, we assumed that there were no substitutes for the patented component, which allowed the patent holder to act as a monopolist in setting license fees among competing manufacturers. In many situations, patents provide no market power because there are perfect (and otherwise unpatented) substitutes for the patented good. In such cases, the exhaustion doctrine—at least via its effect on a patent infringement suit—would be irrelevant since the patent holder would not be able to charge a positive license fee (at least related to the patent’s exclusionary force).²⁹

If existing substitutes for the patented good are imperfect, a patent may provide market (rather than monopoly) power. In this case, the willingness of a consumer to pay for the firm’s good would be constrained by the consumer surplus that the rival goods provide. More formally, suppose that in addition to the firm in question (called Firm 1), there is a competitive fringe of rival firms that produce a homogeneous rival good. As before, there are L potential consumers whose valuation of quality, ϕ , is uniformly distributed over the interval $[0, \Phi]$ and so the probability density of consumers per type is $1/\Phi$. Let us call Firm 1’s product good 1 and the rivals’ product good 2. Let h_1 and p_1 denote the quality and price of good 1, and h_2 and p_2 denote the quality and price of good 2. Suppose $h_1 > h_2$. Consumer of type ϕ will purchase good 1 *iff* $h_1\phi - p_1 > h_2\phi - p_2$. In equilibrium, it must be that $p_1 > p_2$, and consumers of type $\phi \in [\frac{p_1 - p_2}{h_1 - h_2}, \Phi]$ will each buy one unit of good 1, while consumers of type $\phi \in [\frac{p_2}{h_2}, \frac{p_1 - p_2}{h_1 - h_2})$ will each buy one unit of good 2. It is easy to show that

$$q_1 = L \int_{\frac{p_1 - p_2}{h_1 - h_2}}^{\Phi} \left[\frac{1}{\Phi} \right] d\phi = \frac{L}{\Phi} \left[\Phi - \frac{p_1 - p_2}{h_1 - h_2} \right].$$

Note that $q_1 < \frac{L}{\Phi} [\Phi - \frac{p_1}{h_1}]$, which means that Firm 1’s demand curve is now shifted down because of the existence of the substitute good.³⁰ In other words, the willingness to pay for good 1 is now reduced. However, the demand curve for good 1 is still linear in p_1 , and p_2 can be treated as parametric by Firm 1, as good 2 is priced at its marginal cost by a large number of perfectly competitive firms.³¹ Since the results in Propositions 2 and 3 arise from a linear demand curve, Propositions 2 and 3 will continue to hold qualitatively, meaning that Regime NE will be statically more efficient than Regime E when t is small, with the opposite being true when t is large. In fact, the threshold value of t is smaller than before, which means that there is a larger range of t for which Regime E is statically more efficient. This makes sense as the lower is the market power of the patent holder, the less likely is Regime NE going to be statically efficient, as the surplus that can be extracted from price discrimination is going to be lower for any given transaction cost.

²⁹License fees are often charged for other reasons, such as the transfer of know-how or other trade secrets related to the patent, as a part of a portfolio-wide licensing deal, etc.

³⁰In equilibrium, $q_2 = \frac{L}{\Phi} [\frac{p_1 - p_2}{h_1 - h_2} - \frac{p_2}{h_2}]$ and $q_1 + q_2 = \frac{L}{\Phi} [\Phi - \frac{p_2}{h_2}]$. The result that $q_1 < \frac{L}{\Phi} [\Phi - \frac{p_1}{h_1}]$ follows since it must be true that $\frac{p_2}{h_2} < \frac{p_1}{h_1} < \frac{p_1 - p_2}{h_1 - h_2}$.

³¹If the fringe is monopolistically competitive (rather than perfectly competitive), p_2 can still be treated as parametric by Firm 1 as long as the number of firms in the fringe is large and the marginal cost of good 2 is the same for all the firms in the fringe.

5.6 Multi-Component Products

Products with multiple patented components have been subject to much discussion with the rise of computers, mobile phones, televisions, and other goods that often contain numerous components patented by many different patent holders. In these situations, 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—and there is much debate on this issue (e.g., Barnett, 2015)—exhaustion can potentially ameliorate these concerns by reducing the number of inbound licenses needed to manufacture the product.

We can extend our model by allowing for two patented components, x_1 and x_2 , each of which is patented by a different patent holder, P_1 and P_2 . Suppose that the components x_1 and x_2 are intermediate goods manufactured by upstream manufacturers U_1 and U_2 and used in the production of the final good by a downstream manufacturer D . In order to produce the final good, D combines x_1 with x_2 , materials, and factor inputs. Now, interpret ϕ_1 as the willingness of D to pay for good x_1 . The willingness to pay is derived from the profit motive of D . In that case the “consumer surplus” derived from “consuming” good x_1 should be interpreted as “profit” or “producer surplus” of D derived from using the intermediate good x_1 to produce the final good. For example, D ’s willingness to pay for x_1 is equal to the price of the final good minus the unit material cost, the unit input costs, and the per unit royalty paid to P_2 (which is the per unit producer surplus extracted by P_2). In general, this willingness to pay varies across different downstream manufacturers. Thus, the “total surplus” with respect to x_1 is the sum of the producer surplus of P_1 and the producer surplus of D .

Of course, our model is symmetric, with the result that in the presence of transaction costs that are roughly fixed per component—and abstracting away from the increased producer surplus from additional downstream royalties—Regime NE will on balance reduce the total producer surplus of the two patent holders more than in Regime E. If we further assume that the downstream royalties for multi-component products do not differ from a single-component product of equal value, then transaction costs in a multi-component product (with multiple patent owners) will cause more transactional friction and, hence, will burn up more surplus than for a single-component product. In other words, when t is large, there may be a stronger case in support of Regime E for products in which multiple components are patented by different patent holders.

Multi-component products also shift incentives between pioneering and incremental innovation. In a regime of absolute exhaustion (Regime E), P_1 can only license U_1 but not D . However, with opt-out exhaustion (Regime NE), the downstream manufacturer D may need to obtain a license from P_1 (as well as P_2). According to our model, and assuming for a moment that P_1 strikes the first license agreement with D , Regime NE increases the producer surplus of P_1 and reduces the producer surplus that can potentially be extracted by P_2 . In this case, if the patents are asymmetric in their technological significance, then the distribution of surplus between P_1 and P_2 may have significant welfare implications. For instance, if P_1 holds a foundational “upstream” patent that is essential to the final product, while P_2 holds a minor “downstream” patent covering

an optional product configuration. Then as just noted, P_1 can extract surplus that otherwise would have been available to P_2 . In this example, incentives will shift away from minor improvements to pioneering inventions, which—in the aggregate—may or may not be welfare-increasing, depending on the specific characteristics of the technology and other factors at-hand.

6 Qualifications and Implications

In this section, we discuss potential qualifications to our model, then in view of our findings and those qualifications, provide some preliminary policy assessments. We suggest that courts adopt a contextual approach, allowing opt-out depending upon the specific circumstances. We recommend that courts consider at least three factors: (1) the presence or absence of large transaction costs, including negotiation, search, and information costs; (2) the presence or absence of information asymmetries, which in many cases may be proxied by whether the downstream party was provided clear notice of the applicable restrictions; and (3) whether the product is complex (composed of many patented components) or discrete (composed of one or a few patented components).

6.1 Potential Limitations of Our Model

Because our paper is the first formal economic model of domestic patent exhaustion that explicitly incorporates transaction costs (and only the second formal model of domestic exhaustion we are aware of), we have attempted to provide a rigorous yet relatively straightforward framework that provides immediate results. Nonetheless, there are several important aspects of patent exhaustion that we have not modeled.

First, although we considered dynamic efficiencies and costs in Section 5, we did not robustly model these effects of the exhaustion doctrine. From our limited modeling of *ex ante* investment in product quality, there are dynamic benefits to the patent owner from a presumptive exhaustion regime relative to an absolute one. Yet, we assumed in this treatment that only the patent owner invests in product quality. Of course, third parties can also invest in product quality, and to the extent that exhaustion lowers the costs of patented inputs to third party innovation, then a regime of absolute exhaustion could similarly provide dynamic benefits that outweigh any static efficiencies from a presumptive exhaustion regime. In other words, for cumulative innovation, there are at least two competing effects: stronger patent protection in the form of NE renders follow-on innovation more costly, reducing innovation; yet, stronger patent protection in the form of NE increases the profits of the initial innovator, promoting innovation.³² Like patents more generally, determining the optimal level of tradeoffs between static and dynamic efficiencies depends on empirical realities that are likely to vary widely from industry-to-industry and technology-to-technology, making it difficult to arrive at any hard and fast conclusions.

Second, we have assumed that consumers do not resell the patented products they purchase to

³²See, for example, Chor and Lai (2014), which assesses whether stronger patent strength promotes welfare under cumulative innovation.

other consumers. For instance, low-value consumers may engage in arbitrage by selling newly purchased products to high-value consumers. Additionally, consumers may sell used products on a secondary market. Indeed, some scholars (e.g., Heald, 2003) have justified the exhaustion doctrine—at least in the copyright context—on the grounds that it promotes a vigorous resale market, which substantially benefits consumers. Yet, for many patented products, the transaction costs of arbitrage and resale are too high to justify the practice. Alternatively, if the patent owner can track the arbitrage at low monitoring costs, then the consumers will simply become intermediaries, and in a regime of presumptive exhaustion, the patent owner will charge these consumers-intermediaries accordingly. In these instances, our model of presumptive exhaustion would not change qualitatively. However, when arbitrage is viable and monitoring costs are high, the regime of presumptive exhaustion and associated price discrimination will collapse. Specifically, if the patent owner cannot cost-effectively determine who is selling to whom, and at what price, then arbitrage may occur that destroys any of the welfare benefits of price discrimination. In this scenario, presumptive exhaustion begins to approximate absolute exhaustion. Thus, whatever beneficial effects on static and dynamic efficiency that may emerge from a rule of presumptive exhaustion would, in such a scenario, primarily be for naught.

A resale market for used goods, on the other hand, does not clearly help support the imposition of absolute exhaustion. As an initial matter, some goods cannot be resold after they are used, either by definition or in practice. For instance, pharmaceutical drugs and downloaded mobile applications have no resale markets. For products that can be resold, if the patent owner knows that end-consumers can extract additional value from used products, and the owner has market power in the good, then it will just increase the price of the good to reflect any value from resale. In this instance, our model does not qualitatively change. On the other hand, if the patent owner cannot monitor the resale market, then this market is akin to the arbitrage we just described, and again presumptive exhaustion and associated price discrimination will no longer provide the benefits described in our model. Additionally, if the patent owner lacks monopoly power, then either exhaustion is not of any economic concern (in the case of perfect substitutes) or our original result still holds qualitatively (in the case of imperfect substitutes, see Section 5.5). As such, we do not find that the presence of a resale market, at least when the patent owner can monitor it, qualitatively changes our prior discussion.³³

Third, we have assumed that maximizing total surplus is the optimal outcome, foregoing any discussion of distributive benefits from an absolute or presumptive regime of exhaustion. As we noted throughout our discussion, the consumer surplus from a regime of absolute exhaustion will often exceed the consumer surplus in a regime of presumptive exhaustion. If one values consumer surplus more than producer surplus—which, of course, is not standard in economic analysis—then mandatory exhaustion may become more attractive. On the other hand, we also showed that the low-valuation consumers can benefit more from a regime of presumptive exhaustion. Because these consumers are often the least well-off, if one values the surplus of this group more highly, then presumptive exhaustion may be more desirable. And, of course, this all abstracts away from the dynamic effects of exhaustion. If mandatory exhaustion reduces incentives to perform R&D so

³³However, following our finding in Section 5.5, when imperfect substitutes for the patented component are available, a resale market may lower the transaction cost threshold at which absolute exhaustion is more statically efficient than presumptive exhaustion.

much that no products result, then all consumers are clearly worse off. Thus, despite some claims that distributive concerns support a regime of mandatory exhaustion, the reality appears to be more nuanced.

Last, we have ignored deontological concerns, such as autonomy and the interest in receiving notice of one's obligations. Although our discussion of transaction costs nominally includes all manner of these costs, including notice and related information costs, we valued these costs equally with other types of costs, such as negotiation costs. If notice and information costs are considered to be a greater loss than their mere out-of-pocket burden, then our general results could change.

6.2 Implications of Our Findings

The major result of our basic model, extensions, and qualifications is that there is no *a priori* reason to favor absolute or presumptive exhaustion. In this regard, our analysis shows that categorical arguments that “double charging” by the patent owner—for instance, of an upstream manufacturer and a downstream consumer—always results in a windfall for the patent owner are misguided. Rather, our results support the view that one regime or the other may be more efficient depending upon the industry, technology, and product of concern. Thus, assuming judges can make relatively accurate determinations without too much effort with respect to the underlying concerns—and, further, that contractual enforcement is generally not as efficient as patent enforcement of downstream restrictions—we generally view a contextual approach as more fruitful than one that necessarily precludes or allows opt-out in all cases. Based on our model, such an approach should examine at least several factors.

First, are the costs in licensing downstream parties, including the negotiation, information, and search costs, high or low relative to the value of the deal? As these costs become significant relative to the deal size, this would disfavor allowing opt-out, because doing so could burn a large share of social surplus. For instance, if a patent owner attempted to separately license each and every patient undergoing surgery with a particular patented surgical scalpel just prior to each surgical procedure, one might imagine the transaction costs of such contracting might be high relative to the value provided by the scalpel. On the other hand, if the patent owner were licensing large downstream manufacturers that further assemble the patented component with other unpatented components en masse, then transaction costs might be low relative to the deal size. These differences might help account for the relatively greater preference in copyright law than patent law for absolute exhaustion. In the copyright-centric industries, there are often relatively few steps between copyright owner and end-consumer, and enforcement is often against individual end-consumers. In the patent-centric industries, there are often relatively many steps between the patent owner and end-consumer, and enforcement is rarely against individual end-consumers.

Second, courts should determine if there are large information asymmetries between patent holders and intermediaries and consumers. Although this technically may be subsumed under the rubric of information and search costs, sometimes it will be difficult for courts to determine the magnitude of such costs. In this event, whether or not clear notice was provided to the potential downstream licensee may be a useful proxy to determine whether substantial information asymmetries

are present. Namely, the absence of clear notice may signal a preference for enforcing absolute exhaustion, all other factors being equal. With that said, because most defendants in patent infringement cases are not individual, end-consumers, but instead sophisticated intermediaries, one would imagine that in most cases these parties either were on actual notice or constructive notice of potential upstream patents that might be asserted against them. In particular, for exhaustion to apply at all, the upstream sale must be authorized, which by definition requires a license between the patent owner and some upstream party in the supply chain. Thus, sophisticated parties in most cases should be able to trace back through the supply chain to the original licensee without much difficulty. In other cases, sophisticated parties can often demand indemnification from upstream sellers. Thus, in many instances, 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—than simple products comprising one or a few patented components, such as agricultural seeds and pharmaceuticals. As we noted earlier, complex products covered by many patents can exacerbate the effects of high transaction costs. Additionally, it is less clear how dynamic incentives affect complex product innovation than discrete product innovation. For instance, although absolute exhaustion may reduce the surplus enjoyed by upstream patent holders, it may reduce the costs of using patented components in further innovation- or commercialization-related activities by downstream entities. Because complex products often require further downstream innovation and commercialization to achieve viability (Sichelman, 2010), absolute exhaustion may be more attractive, all other factors being equal.

Of course, these three factors leave out other concerns, such as those premised on autonomy or distributive justice. For instance, if courts wish to further the interests of consumers at the expense of overall welfare, then different considerations may apply.

7 Conclusion

This paper offers a formal economic model of domestic patent exhaustion that explicitly incorporates transaction costs in licensing to consumers, and examines how a shift in patent policy from absolute to opt-out patent exhaustion (in which the patent owner can opt-out via contract) affects social welfare. The results show that when transaction costs are low, the regime of opt-out patent exhaustion is socially optimal, at least statically, because it allows welfare-enhancing price discrimination via downstream licensing. Conversely, when transaction costs are high, the regime of opt-out patent exhaustion leads to a greater loss of static efficiency, because transaction cost frictions offset the benefits of price discrimination.

Relaxing the key assumptions of our model by-and-large does not qualitatively change our results. When we account for *ex ante* investment in product quality, we find that dynamic efficiency rises in the regime of opt-out patent exhaustion, and these dynamic gains in promoting *ex ante* investment in product quality may outweigh any loss of static efficiency in the opt-out exhaustion regime when transaction costs are high. Opt-out patent exhaustion is also more likely to dominate

in terms of static efficiency when licensing is via heterogeneous intermediaries, with each intermediary negotiating the license fees on behalf of a large number of consumers. On the other hand, absolute patent exhaustion is more likely to dominate in terms of static efficiency when there is information asymmetry in assessing consumer demand, which acts like an increase in transaction costs. Allowing for positive manufacturer transaction costs does not affect our results. Likewise, easing consumer switching costs does not alter our findings across the variety of transactions engaged in by patent owners. Furthermore, our results continue to hold qualitatively when we allow for substitutes for the patented component or consider goods comprising multiple patented components, though complex products may exacerbate the problems generated by opt-out exhaustion when transaction costs are high.

Our findings confirm and expand upon some of the qualitative results in the literature. First, our findings confirm the proposition of Mulligan (2013, 2016) that exhaustion may reduce rent dissipation when the transaction costs of licensing are high. Specifically, absolute exhaustion prevents the patentee from “burning up” large amounts of surplus via downstream licensing transaction costs, which occurs when the patent holder can require direct licenses from downstream consumers. Second, the results show that for at least a certain class of consumers (i.e., those with high willingness to pay), absolute exhaustion can reduce product prices (Katz, 2016). Our results also support the arguments in Kieff (2008) and Katz (2016) that absolute exhaustion can reduce social efficiency, since it prevents price discrimination via downstream licensing. Our model clarifies that this occurs when transaction costs of licensing to consumers are low. On the other hand, our results reject the proposition in Layne-Farrar et al. (2010) that absolute exhaustion is likely to lead to inefficiencies even with high transaction costs in licensing. We show that when transaction costs in licensing to consumers are high, absolute exhaustion *decreases* static inefficiencies and so is statically superior (though the effects on dynamic efficiency are ambiguous).

In summary, whether absolute exhaustion or presumptive exhaustion is more socially optimal is an empirical question that turns on the specific circumstances at hand. If we assume that other doctrines—such as antitrust law or patent misuse—can police anticompetition, and further assume that contract remedies are insufficient, it is possible to use our model to make some predictions about when one regime is more optimal than another. Largely, the result will turn on transaction costs in licensing. For those steeped in Coasean analysis, perhaps the upshot of our rigorous modeling is not so surprising. If transaction costs are large—roughly, the same order of magnitude per product sold as the value of the product itself—then mandatory exhaustion is more likely to be optimal. If not, presumptive exhaustion is more likely to be optimal.

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