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Public Good Economics and Standard Essential Patents

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ABSTRACT

Standard essential patents have emerged as a major focus in both the public policy and academic arenas. The primary concern is that once a patented technology has been incorporated into a standard, the standard can effectively insulate it from competition from substitute technologies. To guard against the appropriation of quasi-rents that are the product of the standard setting process rather than the innovation itself, standard setting organizations (SSOs) require patentholders to disclose their relevant intellectual property before the standard has been adopted and to commit to license those rights on terms that are fair, reasonable, and non-discriminatory (FRAND).

To date courts and commentators have provided relatively little guidance as to the meaning of FRAND. The most common approach is to impose a uniform royalty based on a percentage over overall revenue. The baseline for setting this uniform royalty is the royalty that the patentholder could have charged had the standard had not been created. In essence, this approach takes the ex ante distribution of entitlements as given and attempts to ensure that the standard setting process does not increase patentholders' bargaining power. However, comparisons to the ex ante baseline do not provide a basis for assessing whether the resulting outcome would maximize economic welfare.

Fortunately, public goods economics can provide an analytical framework for assessing whether a particular licensing structure is likely to maximize economic welfare. Although it is often observed that patentable inventions are public goods, key concepts of public good economics (such as the Samuelson condition that provides public good economics' key optimality criterion) are rarely explored in any depth.

A close examination of public good economics reveals that it has important implications standard essential patents and FRAND. The resulting framework surpasses the current approach by providing a basis for assessing whether any particular outcome is likely to maximize welfare instead of simply taking the existing distribution of entitlements as given and allocating them in the most efficient way.

In addition, the insight that demand-side price discrimination is a necessary precondition to efficient market provision suggests that economic welfare would be maximized if holders of standard essential patents were permitted to charge nonuniform royalty rates. At the same time, the optimal level of price discrimination would allow consumers to retain some of the surplus. It also underscores that the fundamental problem posed by standard essential patents may be strategic behavior and incentive incompatibility. The literature also suggests several alternative institutional structures that can help mitigate some of these concerns.

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INTRODUCTION

In the modern economy, innovation has emerged as a key driver of economic growth,[1] demonstrated eloquently by the increase in the number of patent applications and grant over the past two decades.[2] Under U.S. law, inventors who create innovations that satisfy the requirements of patentability are given the exclusive right to practice their invention as a reward for their innovative activity. To the extent that inventions represent an advance over the prior state of the art, the amount that a patentholder will be able to charge is the difference between the value of their inventions and the value of the next-best technological alternative.

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1 For a classic statement of this position, see JOSEPH A. SCHUMPETER, CAPITALISM, SOCIALISM, AND DEMOCRACY 84–85 (3d ed. 1950).

2 Patent Technology Monitoring Team, U.S. Patent and Trademark Office, U.S. Patent Statistics Chart, Calendar Years 1963–2012 (June 7, 2013 5:59:37 PM), http://www.uspto.gov/web/offices/ac/ido/oeip/taf/us_stat.htm.

Many modern products depend on multiple innovations. When that is the case, consumers and producers often benefit from the creation of an industry standard. Industry-wide adoption of a single standard can reduce costs and reduce uncertainty for firms wishing to produce components of the standard.[3] Standards also provide flexibility for consumers to mix and match different components and can speed innovation by allowing parallel testing of different technological configurations consistent with the standard.[4] The problem is that once a patented technology has been incorporated into a standard, the standard insulates it from competition from substitute technologies. In the process, the incorporation of a patent into a standard can create quasi-rents that are the product of the standard-setting process rather than the innovation itself. The reduction of competition can permit the holder of a patent that has been incorporated into a standard to appropriate more than the incremental value created by their innovation. Instead, patentholders may attempt to appropriate surplus created by other innovations or factors of production in addition to the value created by their innovation.

To prevent this type of opportunistic behavior, standard setting organizations (SSOs) require patentholders to disclose their relevant intellectual property before the standard has been adopted and to commit to license those rights on terms that are fair, reasonable, and non-discriminatory (FRAND). Unfortunately, as two noted commentators observed, “there are no generally agreed tests to determine whether a particular license does or does not satisfy a RAND commitment.”[5] SSOs have yet to provide much guidance as to what FRAND means,[6] and to date, only a single trial court has offered a complete articulation of FRAND in a particular case.[7]

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[3] U.S. DEP’T OF JUSTICE & FED. TRADE COMM’N, ANTITRUST ENFORCEMENT AND INTELLECTUAL PROPERTY RIGHTS: PROMOTING INNOVATION AND COMPETITION 33 (2007), *available at* http://www.justice.gov/atr/public/hearings/ip/222655.pdf.

[4] Christopher S. Yoo, Modularity Theory and Internet Policy (forthcoming 2014), *available at* http://ssrn.com/abstract=2032221.

[5] Daniel G. Swanson & William J. Baumol, *Reasonable and Nondiscriminatory (RAND) Royalties, Standards Selection, and Control of Market Power*, 73 ANTITRUST L.J. 1, 5 (2005).

The academic writing on the subject has attempted to implement FRAND to mimic the royalty that the patentholder could have charged had the standard had not been created.[8] In essence, the objective is to design FRAND to preserve ex ante bargaining power that would have existed in the absence of the standard while preventing the patentholder from exercising any ex post bargaining power created by the standard. In particular, some commentators have concluded that replicating the outcomes of the bilateral negotiations that would have occurred naturally suggests that patentholders should be permitted to charge licensees different amounts based on differences in bargaining power and differences in the incremental value they derive from the patented invention.[9]

Unfortunately, this approach simply assumes that the existing level of patent protection is economically optimal without analyzing whether the alternative institutional form embodied by the standard may affect the analysis. As such, this approach does not provide any basis for assessing whether particular royalty structures would maximize economic welfare. Instead, it takes the ex ante distribution of entitlements as the relevant baseline from the standpoint of economic welfare and innovation and seeks to implement FRAND in a manner that replicates the value of those entitlements.

Fortunately, public goods theory can provide an analytical framework for assessing whether permitting patent holders to charge higher licensing fees to those who value the patent

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[6] Dennis W. Carlton & Allan L. Shampine, *An Economic Interpretation of FRAND*, 9 J. COMPETITION L. & ECON. 531, 532 (2013).

[7] Microsoft Corp. v. Motorola, Inc., Case No. C10-1823JLR, 2013 WL 2111217 (W.D. Wash. Apr. 25, 2013).

[8] *See, e.g.*, Carlton & Shampine, *supra* note 8, at 536–37, 539–40, 541–42, 545–46; Richard J. Gilbert, *Deal or No Deal? Licensing Negotiations in Standard-Setting Organizations*, 77 ANTITRUST L.J. 855, 860 (2011); Swanson & Baumol, *supra* note 5, at 10.

[9] Carlton & Shampine, *supra* note 8, at 540–41; Mario Mariniello, *Fair, Reasonable and Non-Discriminatory (FRAND) Terms: A Challenge for Competition Authorities*, 71 J. COMPETITION L. & ECON. 523, 525, 532 (2011).

more is likely to be efficient.[10] Although it is a commonplace to observe that patentable inventions and similar types of information are public goods,[11] the nuances of public good economics are rarely explored in the literature.[12] This Essay will examine the implications of public good economics for FRAND licensing, paying particular attention to whether permitting differential pricing based on value to individual licensees is likely to be efficient.

I. PUBLIC GOOD ECONOMICS

Public goods are traditionally regarded as having two defining characteristics. First, they are *nonexcludable*, in that firms cannot provide them to one consumer without simultaneously providing them to others as well. Second, they are *nonrival*, in that the consumption by one person does not reduce the supply available for others.[13] Like all forms of information, patentable inventions appear to satisfy both criteria. In the absence of patent protection, inventors who reveal their innovations to others have no viable means for preventing them from being shared with third parties. Moreover, the fact that a patent is shared with one person does not in any way diminish the inventor's ability to share it with any number of other people.

Unfortunately, these assumptions have not been operationalized in the patent literature in a manner that takes into account the full insight of public good economics. For example, the

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10 For overviews of the literature on public goods, see RICHARD CORNES & TODD SANDLER, THE THEORY OF EXTERNALITIES, PUBLIC GOODS, AND CLUB GOODS (2d ed. 1996); and William H. Oakland, *Theory of Public Goods*, *in* 2 HANDBOOK OF PUBLIC ECONOMICS 485 (Alan J. Auerbach & Martin Feldstein eds., 1987).

11 For the seminal statement, see Kenneth J. Arrow, *Economic Welfare and the Allocation of Resources for Invention*, *in* THE RATE AND DIRECTION OF INVENTIVE ACTIVITY: ECONOMIC AND SOCIAL FACTORS 609, 614–16 (Nat'l Bureau of Econ. Research ed., 1962), *available at* www.nber.org/chapters/c2144.pdf.

12 For my initial exploration of public good economics and an application to copyright, see Christopher S. Yoo, *Copyright and Public Good Economics: A Misunderstood Relation*, 155 U. PA. L. REV. 635 (2007).

13 For the seminal statement, see R.A. Musgrave, *Provision for Social Goods*, *in* PUBLIC ECONOMICS: AN ANALYSIS OF PUBLIC PRODUCTION AND CONSUMPTION AND THEIR RELATIONS TO THE PRIVATE SECTORS 124, 126–29 (Julius Margolis & Henri Guitton eds., 1969).

patent literature models nonrivalry most often with the assumption that marginal cost is zero.[14] While the marginal cost pricing problems are real,[15] Samuelson specifically noted in one of his early follow-on papers to his seminal analysis that the provision of public goods would continue to be problematic even if the marginal cost pricing problem were solved.[16]

Simply put, the central feature of public goods is not jointness in production, but rather jointness in consumption. Stated somewhat more formally, nonrivalry allows the same quantity to serve as an argument in both multiple people's consumption functions.[17] Moreover, although producers can adjust the size of a public good by investing more or less to produce it, once the public good has been produced, every consumer consumes a good of the same magnitude. Consider, for example, a fireworks display. One can use more or fewer rockets, but whatever the size of the display, everyone gets the same thing.[18] The same is true of patentable inventions. Inventors can spend more or less in developing their inventions, but once the invention has been created, every licensee receives the same technology. It is for this reason, the benefits of public goods like information are often said to be *indivisible*.[19] Consumers either purchase them or they do not, and all those who purchase them receive precisely the same good.

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[14] *See, e.g.*, Yochai Benkler, *Intellectual Property and the Organization of Information Production*, 22 INT'L REV. L. & ECON. 81, 82 (2002); Amy Kapczynski, *The Cost of Price: Why and How to Get Beyond Intellectual Property Internalism,* 59 UCLA L. REV. 970, 974 (2012); F. Scott Kieff, *Property Rights and Property Rules for Commercializing Inventions*, 85 MINN. L. REV. 697, 727 (2001); Peter Lee, *Toward a Distributive Commons in Patent Law,* 2009 WIS. L. REV. 917, 929; Mark A. Lemley, *Property, Intellectual Property, and Free Riding*, 83 TEX. L. REV. 1031, 1050–54 (2005); Janusz A. Ordover, *Economic Foundations and Considerations in Protecting Industrial and Intellectual Property*, 53 ANTITRUST L.J. 503 (1984); Henry E. Smith, *Intellectual Property as Property: Delineating Entitlements in Information*, 116 YALE L.J. 1742, 1744 (2007).

[15] For the classic analysis, see Harold Hotelling, *The General Welfare in Relation to Problems of Taxation and of Railway and Utility Rates*, 6 ECONOMETRICA 242 (1938). For a modern application to patent, see John F. Duffy, *The Marginal Cost Controversy in Intellectual Property*, 71 U. CHI. L. REV. 37 (2004).

[16] Paul A. Samuelson, *Aspects of Public Expenditure Theories*, 40 REV. ECON. & STAT. 332, 336 (1958).

[17] *Id.* at 334 (noting that public goods "*simultaneously* enter into many persons' indifference curves").

[18] *See* HARVEY S. ROSEN, PUBLIC FINANCE 58–63 (7th ed. 2005).

[19] *See, e.g.*, Arrow, *supra* note 11, at 615–16, 619, 623. Indeed, a leading book-length analysis of public good economics regards the terms "nonrivalry of consumption" and "indivisibility of benefits" as synonymous. CORNES & SANDLER, *supra* note 10, at 8.

Indivisibility of benefits gives rise to the equilibrium characteristics that make public good economics distinctive. Although the economic analysis of public goods has become increasingly formal, the basic intuitions can be easily illustrated by comparing the baseline case of a two-person economy for private goods with the case of a two-person economy of public goods.

A. Private Goods

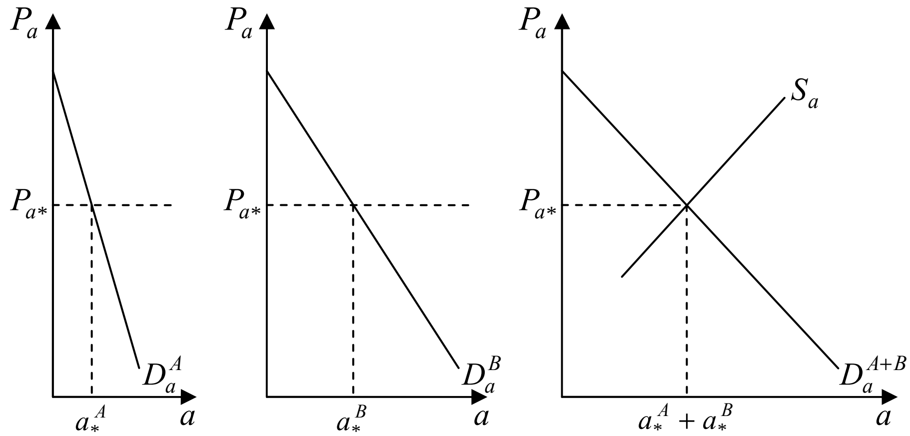
Assume that the society is populated by two people, Alison and Brendan, who each have a demand for apples and oranges.[20] Apples and oranges are excludable, as it is possible to give the benefit to Alison without conveying to Brendan at the same time. Apples and oranges are also rival, in that Alison's consumption of the fruit reduces the supply available for consumption by Brendan and vice versa. Both fruits are also divisible, in that Alison does not necessarily have to consume the same quantity of apples or oranges as Brendan.

Alison's and Brendan's demand curves for apples are depicted in Figure 1. The horizontal axis measures the number of apples (a), and the vertical axis measures the price of apples (P_a). Alison's demand curve is denoted by D_a^A, while Brendan's demand curve is denoted by D_a^B. The market demand curve for apples (D_a^{A+B}) can be determined simply by adding together the quantity of apples that Alison and Brendan would demand at any particular price. The market demand curve is thus the *horizontal* summation of each consumer's individual demand curves. Superimposing a market supply curve (S_a) on the market demand curve allows us to identify the resulting equilibrium. At this point, Alison consumes a_*^A and Brendan consumes a_*^B, and both pay an equilibrium price of P_{a*}. Note that Alison and Brendan do not

[20] This discussion that follows is adapted from HARVEY S. ROSEN, PUBLIC FINANCE 58–63 (7th ed. 2005).

necessarily consume the same amounts. In short, both Alison and Brendan pay the same price and reveal the intensity of their respective preferences by consuming different quantities.

Figure 1: Aggregation of Demand for Private Goods (Horizontal Summation)



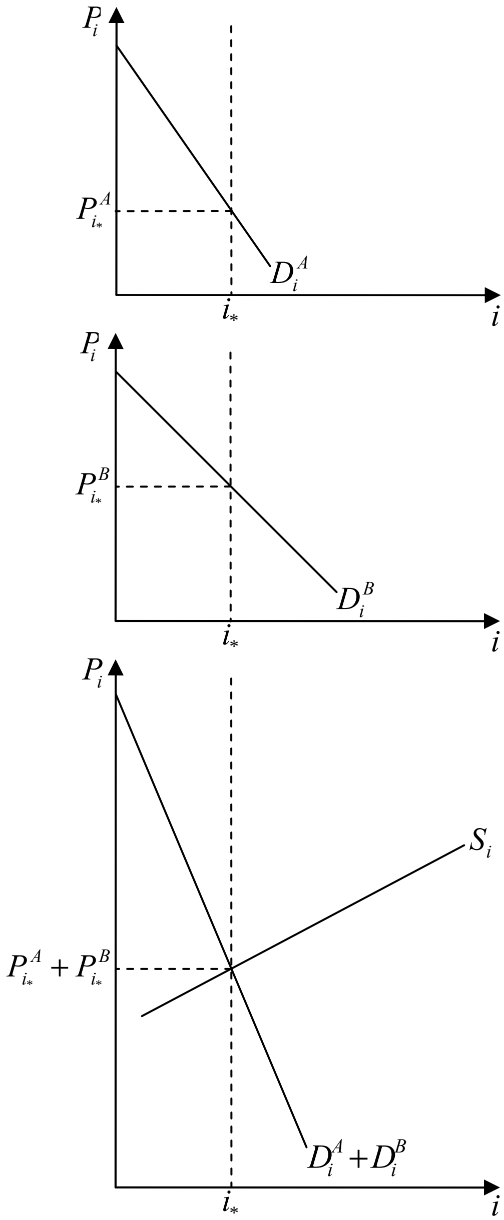
Source: Rosen, *supra* note 20, at 59 fig.4.2.

B. Public Goods

The process of deriving the market demand curve and the resulting equilibria are strikingly different for public goods, such as a patentable invention, *i*. Alison's and Brendan's demands for *i* are represented by D_i^A and D_i^B respectively, with the horizontal axis depicting the number of resources used to produce *i*. Because every person simultaneously consumes exactly the same amount of *i*, the market demand curve (D_i^{A+B}) is the sum of the prices that each consumer would be willing to pay for any particular quantity of *i* ($P_i^A + P_i^B$). In contrast to private goods, where the market demand curve is the *horizontal* summation of the individual demand curves, for public goods, the market demand curve is the *vertical* summation of the individual demand curves.[21]

[21] *See* Paul A. Samuelson, *Diagrammatic Exposition of a Theory of Public Expenditure*, 37 REV. ECON. & STAT. 350, 353–54 (1955) ("[W]e must in the case of public goods add different individuals' curves vertically.").

Figure 2: Aggregation of Demand for Public Goods (Vertical Summation)



Source: Rosen, *supra* note 20, at 62 fig.4.4.

Superimposing a supply curve (S_i) leads to an equilibrium price of $P_{i*}^A + P_{i*}^B$ and an equilibrium quantity of i_*, where Alison's willingness to pay is P_{i*}^A, while Brendan's willingness to pay is P_{i*}^B. Again, Alison and Brendan may place a different value on the good. Because all consumers necessarily consume the same quantity, variations in the intensity can only be reflected by differences in their reservation prices. Thus, in contrast to private goods, where consumers pay the *same price* and signal the intensity of their preferences by consuming *different quantities*, for public goods, individuals consume the *same quantity* and signal the intensity of their preferences by paying *different prices*.

II. IMPLICATIONS

The fact that public goods require the vertical summation of demand has several important policy implications. As an initial matter, it explains why markets tend to systematically underproduce public goods. More importantly for the purposes of this Article, it underscores that side price discrimination based on differences in value is a necessary condition for the efficient production of public goods. At the same time, it shows that price discrimination need not be perfect in the sense that all of the surplus need not be transferred to the producer.

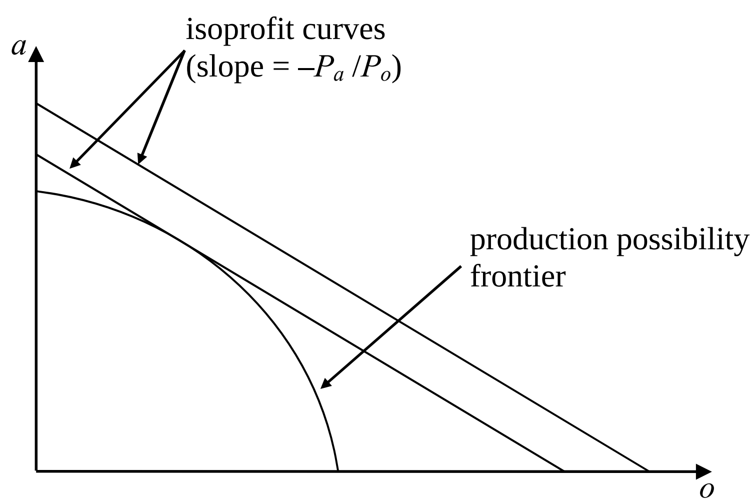
A. Systematic Underproduction of Public Goods

The vertical summation of the demand curves leads to systematic underproduction of public goods. Again, the reasons are well illustrated by comparing an economy consisting of two private goods with an economy consisting of a public good and a private good.

1. Private Goods

In an economy consisting of two private goods, scarcity of resources dictates that society can only produce a limited amount of fruit at any time. The maximum feasible levels of production of both products are represented by the production possibility frontier, which because of the principle of diminishing marginal returns is concave to the origin. The marginal rate of transformation of apples or oranges (MRT_{ao}) is equal to the slope of the production possibility frontier at any particular point. At the same time, producers are willing to forego revenue from one product if they are able to recoup those losses through additional sales of the other product. This tradeoff permits the generation of isoprofit curves along which producers are indifferent, with curves located farther from the origin representing higher levels of profit. The slope of the isoprofit curves is necessarily $–P_a /P_o$. If $MRT_{ao} > –P_a /P_o$, then producers could increase their profits by decreasing their production of apples and increasing their production of oranges until $MRT_{ao} = –P_a /P_o$.

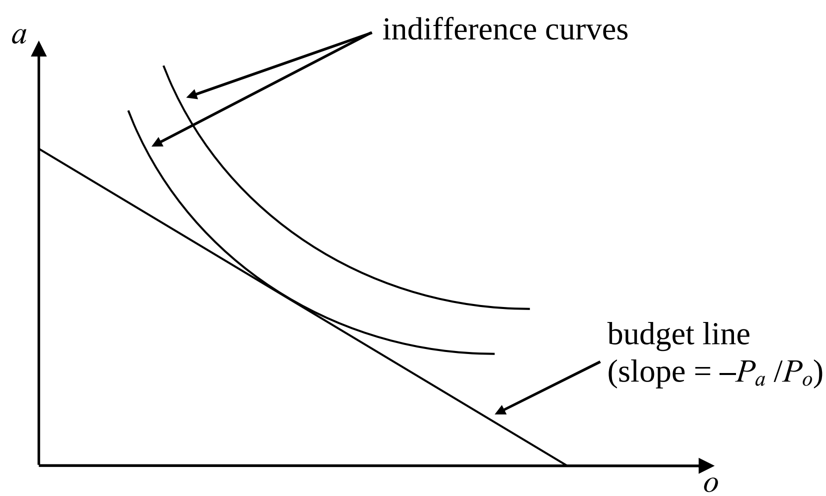
Figure 3: Production in an Economy of Two Private Goods



Source: Rosen, *supra* note 20, at _.

On the demand side, both Alison and Brendan can tradeoff between purchases of apples and oranges subject to a budget constraint, represented by the straight line with slope $–P_a /P_o$ depicted in Figure 4. In addition, both Alison's and Brendan's preferences for the tradeoff between apples and oranges are represented by a series of indifference curves, which are convex to the origin because of the principle of diminishing marginal returns. The indifference curves located farther from the origin represent higher levels of utility. The consumer's marginal rate of substitution of apples for oranges (MRS_{ao}) is represented by the slope along the indifference curve. Consumers have the incentive to achieve the highest level of utility permitted by their budget constraint. If $MRS_{ao} > -P_a/P_o$, then Alison could increase her utility by increasing her consumption of apples and decreasing his consumption of oranges until $MRS_{ao} = -P_a/P_o$, at which point the indifference curve will be tangent to the budget line. This analysis can be applied both to Alison (MRS^A_{ao}) and Brendan (MRS^B_{ao}).

Figure 4: Consumption in an Economy of Two Private Goods



Source: Rosen, *supra* note 20, at 556 fig.A.14.

Markets for private goods thus reach equilibrium where $MRS^A_{ao} = MRS^B_{ao} = -P_a/P_o = MRT_{ao}$. At this point, every consumer receives the highest feasible level of utility, and society maximizes output given the current level of resources, which maximizes economic welfare. Note that neither consumers nor producers can improve their position by changing their activity levels. Consequently, the resulting equilibrium is Pareto optimal. More importantly for our purposes, neither Alison nor Brendan has any incentive to misrepresent the value each places on apples or oranges. Because prices are uniform and set by the market, the only way they can alter their behavior is by changing their levels of consumption for each fruit. However, purchasing more or less of either fruit would only cause their utility to decrease. They thus have no incentive not to reveal the intensity of their preferences truthfully.

2. Public Goods

The situation is quite different for public goods. The fact that every person simultaneously consumes the entirety of the public good means that production of the public good should increase whenever the aggregate marginal benefits to all consumers (not individual consumers) exceeds the marginal cost of increasing production. In other words, production should increase until $MRS_{ao}^{A} + MRS_{ao}^{B} = MRT_{ao}$. Stated slightly more generally, economic welfare is maximized when:

$$\sum_{i} MRS_{io}^{i} = MRT_{io}$$

This is the familiar Samuelson condition widely recognized as the optimality condition that distinguishes public from private goods.

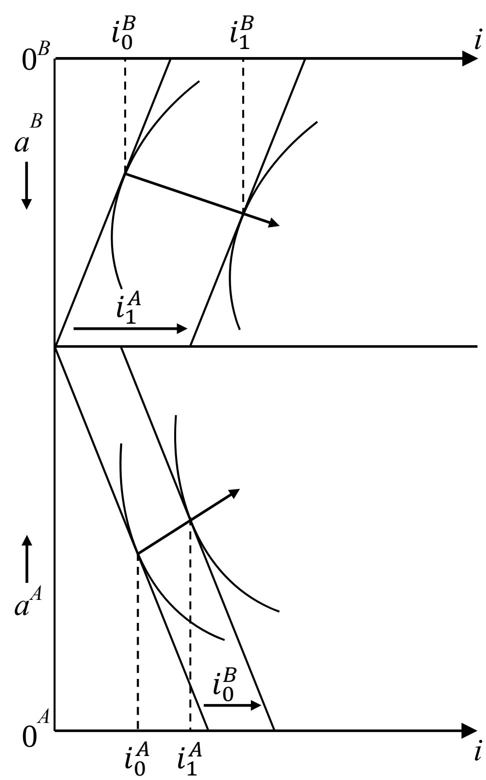
In other words, each person's consumption creates spillover benefits for other people.[22] The problem is that each person will set their own consumption level based on their personal benefit rather than the aggregate social benefits. This will lead them to limit their consumption even when further increases would cause aggregate marginal social benefits from investing more resources in the public good would exceed the marginal cost of doing so. In other words, individuals will consume where their marginal rates of substitution equal $-P_a / P_o$, even though efficiency requires that the *sum* of every consumers' marginal rate of substitution equals this price ratio.[23] As a result, each individual sets their consumption level too low, and the market

[22] CORNES & SANDLER, *supra* note 10, at 27–28.
[23] *Id.* at 27.

necessarily reaches equilibrium at a point inside the horizon of the production possibilities frontier.

The dynamics are depicted in the modified Edgeworth Box in Figure 5. The amount of the public good *i* represented on the horizontal axis. The amount of the private good *a* represented on the vertical axis, with the amount consumed by Alison measured upward (a^A) and the amount consumed by Brendan measured downward (a^B). The length of the vertical axis ($0^A 0^B$) represents the total quantity of *a* that can be produced (and thus consumed), although this can be adjusted upwards or downwards if more resources are allocated to the production of *a*. In the absence of any consumption by the other person, Alison would consume i_0^A, and Brendan would consume i_0^B.

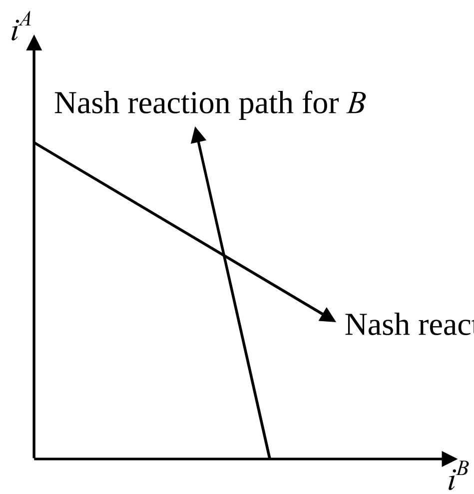
Figure 5: Consumption in an Economy of Public Goods



Source: CORNES & SANDLER, *supra* note 19, at 27 fig.2.2.

Because the public good is simultaneously consumed by both people, Alison automatically receives the i_0^B funded and consumed by Brendan, which effectively shifts her budget line outwards by that amount. The additional resources permits Alison to reach an indifference curve located farther from the origin, at which point she voluntary consumes a quantity of i_1^A. Brendan in turn automatically receives the i_1^A funded and consumed by Alison, which causes him to increase his consumption to i_1^B. It is an easy matter to calculate both Alison's and Brendan's best response function for any quantity consumed by the other person. The intersection between these two curves represents a Nash equilibrium.

Figure 6: Nash Reaction Paths for Public Goods



Source: CORNES & SANDLER, *supra* note 19, at 28 fig.2.3.

Although the fact that each individual bases their consumption decision on their personal marginal rate of substitution (and thus stops short of the welfare maximizing point which is determined by the sum of every individuals' marginal rate of substitution), it is still individually rational for each person to contribute something to the production of the public good. For this reason, the literature refers to the tendency toward underproduction as "easy riding" rather than "free riding."[24] Empirical studies have has confirmed that individuals will make positive, but suboptimal contributions to producing a public good.[25] For the reasons stated above, this equilibrium will necessarily fall below the welfare-maximizing ideal.

B. Demand-Side Price Discrimination as a Necessary Condition for Efficient Market Provision

The Samuelson condition implies that if public goods are to be privately provided, the producer must recover the aggregate marginal benefits accrued by every consumer. Because marginal benefits are likely to differ person to person, this implies that every person should be charged a different price based on the incremental value they place on investing more resources in producing the public good. As noted above, because every consumer receives the entire industry output, individualized priding is the only available instrument for signaling the intensity of preferences and for funding the production of the public good.

Public good economics thus provides an efficiency-based justification for allowing FRAND licensing fees to vary depending on the incremental value that the licensees place on the patented invention.[26] Indeed, the Samuelson condition indicates that such value-based discrimination is a necessary condition for efficient market provision. It also underscores the importance of permitting only those pricing differentials that are based on demand characteristics and not those based on any market power created by the standard setting process.

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[24] For examples, see *id.* at 30; Richard Cornes & Todd Sandler, *Easy Riders, Joint Production, and Public Goods*, 94 ECON. J. 580, 580 n.2 (1984).

[25] For reviews of the literature, see DOUGLAS D. DAVIS & CHARLES A. HOLT, EXPERIMENTAL ECONOMICS 317–75 (1993); John O. Ledyard, *Public Goods: A Survey of Experimental Research*, *in* HANDBOOK OF EXPERIMENTAL ECONOMICS 111, 122–169 (John H. Kagel & Alvin E. Roth eds., 1995).

[26] Carlton & Shampine, *supra* note 6, at 546–47.

C. Expansion of the Range Over Which Price Discrimination Is Relevant

The conventional wisdom under the marginal-cost approach to nonrivalry is that price discrimination is only relevant with respect to those inefficiently excluded from the market, i.e., the quantity represented by the deadweight loss triangle. Price discrimination with respect to inframarginal consumers simply transfers surplus from consumers to producers.

The Samuelson condition suggests a broader scope for price discrimination. Economic efficiency requires charging every consumer the marginal benefit they would derive from investing more resources in the public good (although as we shall see in the next section, the potential for inframarginal transfers may allow some restriction in the range of quantities over which price discrimination is necessary.

D. The Retention of Consumer Surplus

Perfect price discrimination is often criticized for transferring the entire surplus to consumers. Although this maximizes total welfare, it reduces consumer welfare. Indeed, although price discrimination can be efficient, it can increase patent holders' ability to extract surplus (including those associated with the standard rather than the underlying technology).[27]

The Samuelson condition makes clear that market efficiency does *not* require that producers capture the *entire* surplus enjoyed by consumers. Instead, it underscores that producers need only appropriate the aggregate *marginal* benefits enjoyed by consumers. Consumers may retain any inframarginal benefits without preventing the public good from being privately provided.

[27] *Id.* at 549.

The approach to FRAND royalty rates implied by public good economics is consistent with this insight by its requirement that the FRAND license reflect only the licensee's incremental profits, not its full profits.[28] Not only does this satisfy their bargaining-oriented benchmark of leaving the parties in the same position in which they would have been without the standard; it also has the benefit of satisfying the Samuelson condition for economic efficiency.[29] At the same time, it ensures that licensees retain some of the surplus and thus benefit from the innovation.

III. Complications and Potential Advantages

Public good economics thus provides an analytical framework for showing that permitting patentholders to charge different prices to different classes of customers would not only allocate surplus in accordance with the ex ante bargaining power that the parties would have exercised in the absence of the standard. It would also satisfy the conditions for the optimal private production of public goods.

At the same time, public good economics identifies potential institutional obstacles for determining whether FRAND licenses reflect value to the licensee. At the same time, it suggests one way that the standard-setting process might mitigate those problems.

A. Strategic Avoidance of Funding Sunk Costs

The combination of nonrivalry and the fact that consumers retain some amount of the surplus creates incentives for holdup. Considering first nonrivalry, the fact that every consumer

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28 *Id.* at 536.

29 The producer of the public good need not necessarily appropriate the exact marginal benefit from each consumer. As a theoretical matter, the producer could capture inframarginal surplus from some consumers and appropriate less than the full marginal benefit from others. All that the producer cares about is whether its aggregate return equals the sum of every consumer's marginal benefit.

enjoys the benefits of the entire industry output means that consumers benefit from further investments in the public good even when they did not pay for those further investments. This creates the incentive for each consumer to try to induce other consumers into contributing more to the creation of the public good.

If the patentholder were already appropriating all of the available surplus, such a strategy would prove ineffectual, as other consumers would have no surplus they could contribute to financing the public good. The fact that consumers need only contribute the marginal benefits they receive from further investments in the public good and can retain any inframarginal surplus provides incentives for an individual consumer to attempt to induce others to use part of their inframarginal surplus to finance creation of the public good. In essence, consumers have the incentive and the ability to act strategically to induce others to invest part of their surplus that they otherwise would have retained in the public good. If these attempts are unsuccessful, they can exacerbate the systematic underproduction of the public good.

B. Incentive Incompatibility

Another salient problem associated with the private provision of public goods is incentive incompatibility. Because optimality requires that every person consume the same quantity and pay a different price that reflects the benefit they derive from any marginal increases in the amount invested in the public good, idealized public good pricing imposes the same informational requirements associated with any system of perfect price discrimination. In the context of consumer goods, moreover, valuations are completely subjective. Because valuation information is private, individual consumers have both the incentive and the ability to misrepresent their valuation of the public good in an attempt to induce other consumers to bear a larger percentage of the costs.[30] If the patentholder was already appropriating all of the available surplus, such a strategy would prove ineffectual, as other consumers would have no surplus they could contribute to financing the public good. The fact that consumers retain some degree of surplus provides incentives for an individual consumer to attempt to induce others to use part of their inframarginal surplus to finance creation of the public good.

Various scholars have proposed using mechanism design to induce consumers to reveal their true valuations.[31] Perhaps the best known example of mechanism design is the Vickrey auction.[32] Vickrey recognized that participants in auctions in which winners are required to pay the full amount of their final bids have an incentive submit bids that are less than their full valuation. This is because the winner may not have to pay their full valuation if the valuation of the second-highest bidder is considerably lower. The desire to reduce the amount one would have to pay inevitably leads bidders to submit bids that are less than their full valuation even if doing so reduces their chances to win the auction.[33]

Vickrey auctions solve this problem by creating mechanism in which the size of the bid affects the likelihood of winning the auction, but does not affect the amount the winner will actually pay. Under this mechanism, the highest bidder wins the auction, but only has to pay the amount of the second highest bid.[34] Making the amount that winners pay independent of the valuations they report and instead dependent on the valuations that others report eliminates the disincentive to report valuations accurately. In game theoretic terms, this makes reporting one's preferences accurately the dominant strategy. As a result, participants in an auction can bid their

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30 Samuelson, *Public Expenditure*, *supra* note *supra* note 16, at 336; Samuelson, *Diagrammatic Exposition*, *supra* note 21, at 355; Paul A. Samuelson, *The Pure Theory of Public Expenditure*, 36 REV. ECON. & STAT. 387, 388 (1954).

31 *See* CORNES & SANDLER, *supra* note 10, at 214–21; Jean-Jacques Laffont, *Incentives and the Allocation of Public Goods*, *in* HANDBOOK OF PUBLIC ECONOMICS, *supra* note 10, at 537, 554–59.

32 William Vickrey, *Counterspeculation, Auctions and Competitive Sealed Tenders*, 16 J. FIN. 8 (1961).

33 *Id.* at 14–15.

34 *Id.* at 8, 20–21.

full valuation without having to worry that they would have to pay more than the minimum necessary to win the auction.[35]

Edward Clarke and Theodore Groves adapted Vickrey's approach into a mechanism for valuing public goods.[36] The would-producer of the public good invites citizens to submit their full valuations of the public good. The would-be producer then examines whether the cumulative valuations satisfy the Samuelson condition and thus would be socially beneficial. However, each citizen would not pay their full valuation. Instead, they would pay a tax equal to the difference between the total cost of the public good and the sum of all of the other citizens' valuations. The fact that the reported valuation does not directly affect the amount that any citizen has to pay eliminates the incentive for citizens to understate their true valuations.[37]

This mechanism is subject to a number of limitations. As an initial matter, the mechanism presumes that all of the potential beneficiaries of the public good can be identified and addressed at one time. It also requires a third party who can be trusted to implement the mechanism faithfully, and the mechanism must not be subject to renegotiation after the preferences are revealed. In addition, this mechanism functions only if preferences are single peaked.[38]

Most importantly, the model assumes that each individual's valuation is independent of their income and that the money paid does not provide any incremental benefits.[39] Moreover, allowing the revenue raised by the auction to inure to the benefit of the bidders would destroy the independence between the amounts bid and the amount paid that is the key to maintaining

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35 CORNES & SANDLER, *supra* note 10, at 115.

36 Edward H. Clarke, *Multipart Pricing of Public Goods*, 11 PUB. CHOICE 19 (1971); Theodore Groves & Martin Loeb, *Incentives and Public Inputs*, 4 J. PUB. ECON. 211 (1975).

37 CORNES & SANDLER, *supra* note 10, at 223–24.

38 Laffont, *supra* note 31, at 550. Further worked has applied the framework to a broader set of preferences, although restrictive assumptions still apply. Theodore C. Bergstrom & Richard C. Cornes, *Independence of Allocative Efficiency form Distribution in the Theory of Public Goods*, 51 ECONOMETRICA 1753 (1983).

39 CORNES & SANDLER, *supra* note 10, at 227.

incentive compatibility. This means that the contributions to the production of the public good that exceed the cost of producing it must not be returned to the citizens. Otherwise the amounts bid would have an impact on the amounts paid and would destroy the decoupling of these two considerations that preserves the incentive to reveal valuations truthfully.[40] Later work created mechanisms that eliminate the surplus that must be "wasted," but that mechanism incorporates the weaker equilibrium concept of Nash equilibrium, that is, that people have the incentive to report their preferences truthfully if everyone else is doing so.[41] It also requires that information about every actor's payoff structure be public, and the fact that these valuations are not public is what led to the incentive incompatibility problem in the first place.[42]

The theoretical literature on public goods has thus not come up with a complete solution to the incentive compatibility problem. One potential saving grace in the context of FRAND is that the relevant valuations are for commercial projects, not personal consumption. As a result, the presence of downstream retail markets may provide a more tractable basis for determining valuations. If the FRAND license is a major determinant of the downstream price, any attempt at valuation would be inherently circular, in that the size of the licensing fee would depend on the downstream price, while the downstream price would depend primarily on the size of the licensing fee. Such circularity would not be determinative, however, if the patent must be combined with other inputs and represents only a small percentage of the overall cost of the finished good.

[40] *Id.* at 121, 228.

[41] Theodore Groves & John O. Ledyard, *Some Limitations to Demand Revealing Processes*, 29 PUB. CHOICE 107 (1977).

[42] CORNES & SANDLER, *supra* note 10, at 233–34.

C. Standards as Bundling

There is one sense in which incorporating a patent into a standard may make it easier to engage in price discrimination.[43] As George Stigler noted in his seminal analysis of block booking,[44] bundling the patent with other inputs whose demands are inversely correlated makes it easier to extract surplus with a simple, one-part price.[45] To use a modified form of Stigler's example, assume that a firm is offering two products to two buyers with the prices are noted in Figure 5. If the producer sells the products separately, it will maximize profits by pricing Product 1 at $7 (achieving two sales) and pricing Product 2 at $2.50 (achieving two sales) for a total revenue of $19. If the producer instead sells products as a bundle, it can charge $10. Since both customers value both products at $10 or more, the producer can increase its revenue to $20. The key is that the buyers' demands for the products are negatively correlated. Part of Buyer A's surplus for Product 1 helps fund Product 2, and part of Buyer B's surplus for Product 2 helps fund Product 1. With private goods, it is possible that bundling can create welfare loss by inducing customers to purchase goods even when their reservation price falls below the marginal cost of producing another unit of that good.[46] Fortunately for our purposes, such a concern is irrelevant for information goods for which marginal cost is effectively zero.[47]

Figure 5: Bundling of Two Products with Negatively Correlated Demands

	Buyer A	Buyer B

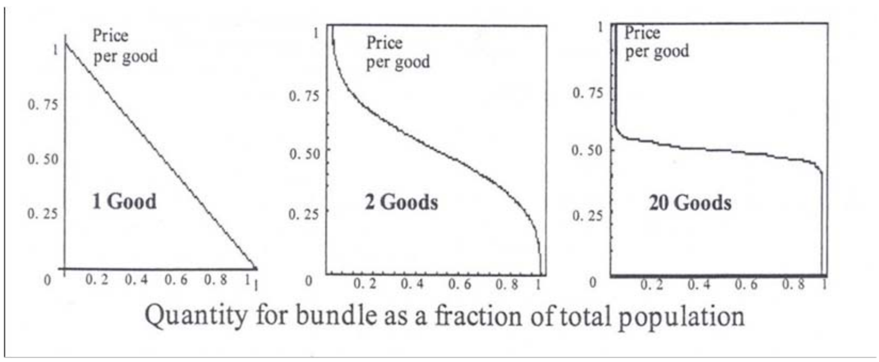
[43] For an earlier discussion of bundling, see Christopher S. Yoo, *Rethinking the Commitment to Free, Local Television*, 52 EMORY L.J. 1579, 1706–09 (2003).
[44] George J. Stigler, United States v. Loew's Inc.*: A Note on Block-Booking*, 1963 SUP. CT. REV. 152.
[45] For prominent extensions of Stigler's analysis, see, e.g., William James Adams & Janet L. Yellen, *Commodity Bundling and the Burden of Monopoly*, 90 Q.J. ECON. 475 (1976), and Richard Schmalensee, *Commodity Bundling by Single-Product Monopolies*, 25 J.L. & ECON. 67, 70–71 (1982).
[46] *See* Adams & Yellen, *supra* note 45, at 492; Barry Nalebuff, *Bundling* 3 (Yale ICF Working Paper No. 99-14, Nov. 22, 1999), *available at* http://ssrn.com/abstract=185193.
[47] Yannis Bakos & Erik Brynjolfsson, *Bundling Information Goods: Pricing, Profits, and Efficiency*, 45 MGMT. SCI. 1613, 1617 (1999); Michael A. Salinger, *A Graphical Analysis of Bundling*, 68 J. BUS. 85, 86, 92–95 (1995); Schmalensee, *supra* note 45, at S228–29.

Product 1	$8,000	$7,000
Product 2	$2,500	$3,000

Source: George J. Stigler, United States v. Loew's Inc.*: A Note on Block-Booking*, 1963 SUP. CT. REV. 152, 153.

Subsequent work has shown that bundling facilitates the extraction of surplus any time the buyers' demands for the bundle components are independently correlated.[48] As Figure 6 indicates, the variance narrows and demand flattens still further as the number of products added to the bundle increases.

Figure 6: Bundling of Goods with Independently Correlated Demands



Source: Bakos & Brynjolfsson, *supra* note 47, at 1617 fig.1.

Reducing the heterogeneity of customers' preferences flattens the aggregate demand curve, which makes it easier to extract surplus through simple one-part pricing.[49] As such, the informational requirements for this form of price discrimination are much simpler.

48 In short, the sum of the variances tends to be greater than the variance of the sum. This is because $(\sigma_{1+2})^2 = (\sigma_1)^2 + (\sigma_2)^2 + 2\rho\sigma_1\sigma_2$, where $(\sigma_{1+2})^2$ represents the variance of a bundle of goods 1 and 2, and $(\sigma_1)^2$ and $(\sigma_2)^2$ represent the variance of each component. Since $(\sigma_1 + \sigma_2)^2 = (\sigma_1)^2 + (\sigma_2)^2 + 2\sigma_1\sigma_2$, this implies that $\sigma_{1+2} < \sigma_1 + \sigma_2$, unless the demands for the components are perfectly correlated, in which case the two sides of this equation will equal each other. *See* Schmalensee, *supra* note 45, at S219–21.

49 *See* Mark Armstrong, *Price Discrimination by a Many-Product Firm*, 66 REV. ECON. STUD. 151 (1999); Bakos & Brynjolfsson, *supra* note 47, at 1614, 1616, 1619; R. Preston McAfee et al., *Multiproduct Monopoly, Commodity Bundling, and Correlation of Values*, 104 Q.J. ECON. 371, 372, 377–80 (1989); Salinger, *supra* note 47, at 92–93 (1995); Schmalensee, *supra* note 45, at S220, S228.

CONCLUSION

The connection between patents and intellectual property has long been accepted, but to date, the literature has done little to explore the connection. A close analysis of public goods theory reveals a number of insights that can help inform courts and policymakers charged with addressing standard essential patents and interpreting FRAND requirements.

The dominant approach to standard essential patents reflected in the academic literature takes the existing distribution of entitlements as given and simply tries to set FRAND royalties to mimic what would have been the outcome of bilateral negotiations had the standard not been created. Public good economics provides a standard for determining the welfare-maximizing outcome that does not simply try to replicate the status quo.

In addition, public good economics reveals that demand-side price discrimination is a necessary condition for efficient market provision. In the process, it shows that such price discrimination must occur over the entire range of production, but allows consumers to retain some of the resulting surplus.

The literature also points out that incentive incompatibility remains a central problem and identifies some alternative institutional solutions that might provide a starting point for the search for mechanisms that are incentive incompatible. In all of these ways, a more complete appreciation of the relevance of public good economics can help shape patent policy in important and constructive ways.