

**Modeling Patent Damages:
Rigorous and Defensible Calculations**

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I. INTRODUCTION

Damages in the majority of patent infringement cases involve a reasonable royalty, lost profits, or a combination of the two. The patent statute provides only limited guidance for quantifying these damages, articulating a standard that an award shall be “adequate to compensate for the infringement, but in no event less than a reasonable royalty” and may include interest, costs, and trebling at the discretion of the court.¹ A reasonable royalty on infringing sales is therefore a floor on damages, but plaintiffs may prove lost sales and price erosion that exceed this amount.²

The leading patent damages cases over the past 30 years have two main features from an economic point of view. First, they demonstrate how the parties and the courts can arrive at starkly different conclusions about “adequate” compensation starting from the same set of facts. For example, in *Georgia-Pacific*, the most famous royalty case, the defendant asserted a royalty between \$1.50 and \$3 per unit while the plaintiff claimed a minimum royalty of \$50.³ The judge awarded the \$50 royalty but the appeals court criticized this as a “basic error” and reduced the rate to \$35.65.⁴ In *Panduit*, the foundational lost profits case, the plaintiff had sought total lost sales and price erosion of \$4.9 million (over \$15 million in today’s terms).⁵ The special master to the district court set lost profits at zero after concluding there was an “acceptable non-infringing substitute.” The appellate decision then found that the special master was “in error” about substitutes but finally denied lost profits anyway due to deficiencies in the plaintiff’s profit margin calculation on the claimed lost sales.

Second, the decisions, particularly at the Federal Circuit level, demonstrate an increasing reliance on economic principles. Legal and economic analyses are converging, a development that is steadily increasing the quality of damages work and clarifying the range of issues that need to be considered. The centrality of economics in this regard was recently emphasized by the Federal Circuit in *Crystal Semiconductor*, a price erosion case that demanded “credible economic evidence to show the decrease in sales, if any, that would have occurred at the higher hypothetical price.”⁶ More generally, sophisticated cases such as *Crystal Semiconductor*, *Grain Processing*⁷, *Micro Chemical*⁸, and *Integra Lifesciences v. Merck KgaA*⁹ underscore the

¹ 35 U.S.C. § 284

² Infringement of a design patent has an additional remedy of disgorgement of the infringer’s profits under 35 U.S.C. §289: However, this article will not further discuss disgorgement damages.

³ *Georgia-Pacific Corp. v. United States Plywood Corp.*, 318 F.Supp. 1116, 1119.

⁴ 446 F.2d 295, 299.

⁵ *Panduit Corp. v. Stahlin Bros. Fibre Works, Inc.*, 575 F.2d 1152.

⁶ *Crystal Semiconductor Corp. v. Tritech Microelectronics Int’l, Inc.*, 246 F.3d 1336.

⁷ *Grain Processing Corp. v. Am. Maize-Prods. Co.*, 893 F.Supp. 1386.

importance of insightful use of the economic evidence. Large monetary implications often hang in the balance. Both for lost profits and reasonable royalties, courts are setting high standards for this analysis that lawyers ignore at their peril.

The main goal of this article is to explain a number of recent advances in economic analysis that contribute to the analysis of patent infringement damages. Specifically, the research to be described addresses a) determination of a reasonable royalty, b) consistent analysis of a lost profits claims with price erosion; c) determination of the amount of price erosion; and d) appropriate use of the split award. These methods draw on standard economic principles that have been widely employed in legal settings, especially intellectual property, antitrust, and commercial damages, and yield the type of “credible economic evidence” that can be brought to bear in a patent case. Moreover, they have a conceptual basis that closely parallels the logic of the Federal Circuit in regard to damages. This article will introduce the key ideas in this work and show how they can be applied in practice.

To set the stage for the discussion, this article begins with an overview of the main legal precedents and economic principles that are generally used to quantify reasonable royalty and lost profits claims. This overview is intended for readers with little or no background in the area. The orientation reflects the training of the author, an economist, but is organized with reference to the most widely cited opinions. Many useful commentaries by lawyers are available elsewhere that provide additional insight into purely legal issues.¹⁰

In outline, Section II provides the overview of the reasonable royalty. Section III is an analogous treatment of lost profits, including lost sales and price erosion. Section IV focuses on the recent economic advances that are the primary message of this article. Section V offers some brief conclusions.

II. THE REASONABLE ROYALTY

A reasonable royalty is usually defined in the cases as an amount “which a person, desiring to use a patented article, as a business proposition, would be willing to pay as a royalty and yet be able to use the patented article at a reasonable profit.”¹¹ This has been interpreted to refer to a hypothetical royalty negotiation that would take place prior to the first infringement.¹²

This definition rests on two key concepts. The time dimension is critical: the royalty should depend only on information that was available no later than the date the infringement began. Introducing later market developments can greatly distort the analysis. For example, a new product may turn out to be enormously successful even though all of the projections prior to

⁸ *Micro Chemical, Inc. v. Lextron, Inc. and Turnkey Computer Systems, Inc.*, 317 F.3d 1387.

⁹ *Integra Lifesciences I, Ltd. v. Merck KGaA*, 331 F.3d 860; 66 U.S.P.Q.2D (BNA) 1865.

¹⁰ Paul M. Janicke, *Contemporary Issues in Patent Damages*, 42 *Am. Univ. L. Rev.* 691 (1993); Allan N. Littman, *Monopoly, Competition, and Other Factors in Determining Patent Infringement Damages*, 38 *IDEA* 1 (1997); and Joel Meyer, *State Industries v. Mor-Flo and the Market Share Approach to Patent Damages: What is Happening to the Panduit Test?*, 6 *Wis. L. Rev.* 1369 (1991).

¹¹ *See Panduit Corp. v. Stahl Bros. Fibre Works, Inc.*, 575 F.2d 1152, 1158.

¹² *Georgia-Pacific Corp. v. United States Plywood Corp.*, 318 F. Supp. 1116, 1120; 166 U.S.P.Q. (BNA) 235.

launch were for modest profitability. An ex post royalty could be high while the ex ante royalty should be low (and vice versa). *Integra Lifesciences v. Merck KgaA* is a notable recent example of a royalty that was overturned in part due to failure to frame the hypothetical negotiation as of the appropriate date.

The second issue is arriving at a workable value for “reasonable profit,” a term that is not defined in economics or accounting. The cases are not very clear or consistent on this point but it has potentially vital implications for the royalty. Recent economic analysis advocates conceiving of reasonable profit as the expected return on the infringer’s next best investment at the time of the hypothetical negotiation.¹³ Such a calculation is reasonable in the sense that it is available to the infringer and so should be able to constrain the terms of the negotiation with the patent holder. This return can range from as high as the return on the infringing project (if an equally good alternative investment was available) down to the infringer’s cost of capital (a floor value that is well-defined in the field of corporate finance). On this basis, the reasonable profit for purposes of the royalty is determined by a fact-based financial analysis of the infringer’s business alternatives.

A. The Georgia-Pacific Factors

For over 30 years the often-cited Georgia-Pacific factors have been the starting point for a reasonable royalty analysis.¹⁴ The factors are:

1. The royalties received by the patentee for the licensing of the patent in suit, proving or tending to prove an established royalty.
2. The rates paid by the licensee for the use of other patents comparable to the patent in suit.
3. The nature and scope of the license, as exclusive or non-exclusive; or as restricted or non-restricted in terms of territory or with respect to whom the manufactured product may be sold.
4. The licensor's established policy and marketing program to maintain his patent monopoly by not licensing others to use the invention or by granting licenses under special conditions designed to preserve that monopoly.
5. The commercial relationship between the licensor and licensee, such as, whether they are competitors in the same territory in the same line of business; or whether they are inventor and promoter.
6. The effect of selling the patented specialty in promoting sales of other products of the licensee; the existing value of the invention to the licensor as a generator of sales of his non-patented items; and the extent of such derivative or conveyed sales.
7. The duration of the patent and the term of the license.

¹³ Roy J. Epstein and Alan J. Marcus, *Economic Analysis of the Reasonable Royalty: Simplification and Extension of the Georgia-Pacific Factors* 85 JPTOS (July, 2003).

¹⁴ *Georgia-Pacific Corp. v. United States Plywood Corp.*, 318 F. Supp. 1116, 1120; 166 U.S.P.Q. (BNA) 235.

8. The established profitability of the product made under the patent; its commercial success; and its current popularity.
9. The utility and advantages of the patent property over the old modes or devices, if any, that had been used for working out similar results.
10. The nature of the patented invention; the character of the commercial embodiment of it as owned and produced by the licensor; and the benefits to those who have used the invention.
11. The extent to which the infringer has made use of the invention; and any evidence probative of the value of that use.
12. The portion of the profit or of the selling price that may be customary in the particular business or in comparable businesses to allow for the use of the invention or analogous inventions.
13. The portion of the realizable profit that should be credited to the invention as distinguished from non-patented elements, the manufacturing process, business risks, or significant features or improvements added by the infringer.
14. The opinion testimony of qualified experts.
15. The amount that a licensor (such as the patentee) and a licensee (such as the infringer) would have agreed upon (at the time the infringement began) if both had been reasonably and voluntarily trying to reach an agreement; that is, the amount which a prudent licensee—who desired, as a business proposition, to obtain a license to manufacture and sell a particular article embodying the patented invention—would have been willing to pay as a royalty and yet be able to make a reasonable profit and which amount would have been acceptable by a prudent patentee who was willing to grant a license.

This list is simultaneously daunting but arguably incomplete. The original opinion described it simply as “some of the factors *mutatis mutandis* seemingly more pertinent to the issue.” The overriding problem is that the factors typically can be used to justify a very wide range of outcomes. There is no coherent framework to assess the quantitative contribution of each factor to a bottom-line royalty, casting doubt on the reliability of the conclusions advanced on either side.

In the author’s view, more explicit financial modeling of the infringer’s activities is a feasible and methodologically sound next step that can significantly improve the analysis specified by the Georgia-Pacific factors. An economic model to achieve this goal is described in Section IV (the FIRRM model).

B. Royalty Surveys

The Georgia-Pacific factors invite the use of actual negotiated royalties as benchmarks. Comparables are always desirable in a damages analysis but they can be treacherous. It is necessary to control for many different license characteristics. However, the number of publicly disclosed royalty rates is limited, as is the amount of information on the terms of each license. There are probably few cases where an arm’s length royalty is available for a similar product negotiated at a similar time under similar terms for a similarly situated infringer/licensee.

Ensuring comparability raises a host of issues. License terms involving duration, field of use, and exclusivity, can vary widely. A particular rate may reflect a larger transaction in IP that includes cross-licenses. There may be non-cash features such as know-how transfer and product support that obscure the stand-alone value of the patent. There are also potential “royalty stacking” issues: the total royalty resulting from piecemeal adding up of royalties from a database may exceed the level that is consistent with profitability of the project as a whole. In addition, *Integra Lifesciences v. Merck KgaA* emphasized that different projects can face very different amounts of risk.

Royalty databases are generally organized fairly broadly by industry and may contain a wide range of rates. Even so, particularly valuable royalties, which are often the ones that are litigated, may be underreported to preserve confidentiality, which would make the database unrepresentative. Experts in a damages proceeding often select an average value for lack of more detailed information, but this choice may not reflect the economic circumstances of either the infringer or the patent holder. Indeed, defensible choice of a single rate when there is a significant range of candidates implies the need for a suitable analytical framework. This is another strong argument in favor of more explicit financial modeling of the infringing activity to supplement, if not replace, the results of a royalty survey.

C. The 25% and 5% Rules

Two shortcuts divorced from economic analysis are sometimes used to arrive at a royalty rate. The “25% rule” simply assigns the licensor a royalty equal to 25% of the infringer’s pretax gross profit during the damages period.¹⁵ This number is essentially arbitrary. Because it is based on ex post results, it does not necessarily relate to the results of a negotiation that took place prior to the infringement. It could be considerably higher or lower than a more careful analysis would indicate. The fiction of the 25% rule is hardly justified by its convenience.

The “5% rule” is similar. This approach sets the royalty at 5% of the infringer’s sales. Even if 5% is close to an average rate in royalty databases, many infringements concern technologies that may have above-average value. Using a 5% rate can therefore also introduce a bias. In *SmithKline Diagnostics v. Helena*, for example, the plaintiff sought a 48% rate and the court eventually awarded 25% (of revenue, not profits).¹⁶

The 25% rule and the 5% rule in general are incompatible as a matter of logic. This is not widely understood but it underscores the essential arbitrariness of these two procedures. They yield equivalent results only when the infringer’s profit margin is 20%.¹⁷ The 25% rule generates a higher royalty if the profit margin is above this level; otherwise the 5% rule is higher. They provide no basis for choosing one over the other when they diverge.

¹⁵ See Russell L. Parr, *Intellectual Property Infringement Damages* at 169.

¹⁶ *SmithKline Diagnostics, Inc. v. Helena Laboratories Corp.*, 1989 U.S. Dist. LEXIS 14761; 12 U.S.P.Q.2D (BNA) 1375.

¹⁷ Suppose revenue was \$100 and profits were \$20 (i.e., 20%). The 5% of sales royalty would yield \$5, as would 25% of \$20. This equivalence would not hold for a profit rate other than 20%.

III. LAW AND ECONOMICS OF LOST PROFITS

A. Lost Sales Damages

1. “But-For” Causation

Damages from lost sales are based on the premise that the patent holder would have made additional sales and associated profits in the absence of the illegal competition from the infringer. Lost sales damages are limited to the patent holder’s provable loss; recovery based on the illegal gain made by the infringer is not permitted. The main issues requiring proof are accordingly (1) the number (or dollar value) of lost sales and (2) the patent holder’s profit margin on such sales. That is, the basic framework is to ask what the profits of the patent holder would have been “but for” the infringement. The difference between but-for and actual profits is the measure of damages.

This but-for approach is well-established in the patent area and is also commonly used in other claims involving economic loss. The main case on point, *Aro Mfg. v. Convertible Top Replacement*, dates back nearly 40 years and has been cited innumerable times.¹⁸ This principle is essential to isolate the economic effect of the accused behavior, both to include all relevant elements of loss and to avoid counting injury that would have occurred regardless of the infringement. As restated by the Federal Circuit in *Rite-Hite Corp. v. Kelley*, “This surely states a ‘but for’ test...If a particular injury was or should have been reasonably foreseeable by an infringing competitor in the relevant market, broadly defined, that injury is generally compensable absent a persuasive reason to the contrary.”¹⁹ The necessity of the but-for standard was reiterated in *Grain Processing*: “this court requires sound economic proof of the nature of the market and likely outcomes with infringement factored out of the picture.”²⁰ As applied in that case, the defendant “would have sold the same product, for the same price, as the actual AMP did, and GPC cannot establish lost profits....this shortcoming is fatal.”²¹

2. Market Definition

An economics-based approach to proving lost sales generally begins with the task of defining the relevant market. Market definition has long been a staple part of antitrust cases and it has equally profound implications in patent infringement. The relevant market identifies what products and which firms compete with the patent holder. As a threshold matter, the market definition establishes whether the patent holder and the infringer compete, which is a prerequisite for lost sales to exist. If they are not competitors, then a reasonable royalty is the appropriate remedy.

¹⁸ *Aro Mfg. Co. v. Convertible Top Replacement Co.*, 377 U.S. 476, 507 (“[In patent infringement cases t]he question to be asked in determining damages is ‘how much the patent holder and licensees suffered by the infringement’, which is primarily the amount the patent holder-licensee would have made if there had been no infringement.”) (quoting *Livesay Window Co. v. Livesay Indus., Inc.*, 251 F.2d 469, 471 (5th Cir. 1958)).

¹⁹ 56 F.3d 1538, 1545, 1546, 35 U.S.P.Q.2d (BNA) 1065 (Fed. Cir. 1995) (en banc).

²⁰ *Grain Processing v. American Maize Prods.*, 979 F.Supp 1233, 1236 (N.D.Ind 1997).

²¹ *Grain Processing Corp. v. American Maize-Products Co.*, 893 F. Supp. 1386, 1392.

The market definition therefore provides the basis for comparing competition in the actual and but-for markets. In particular, if the infringer was the only other player in a “two supplier market,” then the patent holder would have a but-for monopoly. In this case, the patent holder would make all of the infringing sales (in the absence of price erosion, a frequently overlooked condition).²² When the patent holder would face but-for competition, the market definition identifies the universe of firms that must be considered to measure economically meaningful market shares.

The techniques of market definition have been well-developed in antitrust economics. The *Horizontal Merger Guidelines*²³ promulgated by the U.S. Department of Justice and the Federal Trade Commission specify the principal relevant evidence as follows:

- Buyers who have shifted or have considered shifting purchases between products in response to relative changes in price or other competitive variables;
- Sellers who base business decisions on the prospect of buyer substitution between products in response to relative changes in price or other competitive variables;
- Influence of downstream competition faced by buyers in their output markets; and
- Timing and costs of switching products.

*Brown Shoe*²⁴ is the main case that sets forth additional criteria for market definition, including “the reasonable interchangeability of use or the cross-elasticity of demand between the product itself and the substitutes for it...but within this broad market well- defined submarkets may exist which in themselves constitute product markets for antitrust purposes; the boundaries of such a submarket may be determined by examining such practical indicia as industry or public recognition of the submarket as a separate economic entity, the product's peculiar characteristics and uses, unique production facilities, distinct customers, distinct prices, sensitivity to price changes, and specialized vendors.” More recently, sophisticated econometric and consumer survey methods have also been used to help define markets.²⁵ In practice, the level of detail of the market definition analysis will depend on the amount and quality of available data to evaluate these factors.

The Federal Circuit’s decision in *BIC Leisure v. Windsurfing* is a case study in the relevance of market definition for lost sales.²⁶ The patent holder sold high-performance sailboards with retail prices of about \$600. The infringer sold more recreational models at a considerably lower average price, about \$350. Market definition often turns on whether such price differences are consistent with consumers viewing the respective products as acceptable substitutes. The patent holder essentially argued that all sailboards belonged in a single market and that lost sales should be awarded based on its “market share” of the infringing sales.

²² See Roy J. Epstein, *State Industries and Economics: Rethinking Patent Infringement Damages*, 9 Fed. Cir. B.J. (2000) at 370.

²³ 1992 Horizontal Merger Guidelines [With April 8, 1997, Revisions To Section 4 On Efficiencies], ¶1.11, available at http://www.usdoj.gov/atr/public/guidelines/horiz_book/hmg1.html.

²⁴ *Brown Shoe Co., Inc., V. United States*, 370 U.S. 294; 82 S. Ct. 1502; 8 L. Ed. 2d 510.

²⁵ See Jonathan B. Baker and Daniel L. Rubinfeld, "Empirical Methods in Antitrust Litigation: Review and Critique," 1 *Am. Law and Econ. Rev.*, 386-435.

²⁶ *BIC Leisure Prods., Inc. v. Windsurfing Int'l, Inc.*, 1 F.3d 1214, 27 U.S.P.Q.2d (BNA) 1671 (Fed. Cir. 1993).

However, the court focused on the fact that numerous non-infringing and inexpensive sailboards would remain in the but-for market and refused to assign lost sales in this way. That is, “the sailboard market was not a unitary market” as far as the patent holder and infringer were concerned. Lost sales were *not* awarded and the case was remanded for recalculation of royalty damages only.

3. The Panduit Factors

The appellate opinion in *Panduit v. Stahl Bros. Fibre Works* in the 1970’s introduced the famous four-pronged test for lost sales damages that continues to be widely employed in patent infringement cases. This test requires the patent holder to prove all of “(1) demand for the patented product, (2) absence of acceptable non-infringing substitutes, (3) his manufacturing and marketing capability to exploit the demand, and (4) the amount of the profit he would have made.”²⁷ Failure to satisfy at least one of the prongs is sufficient for the Panduit test to deny lost sales entirely. Application of each of the four factors has been refined in later cases.

a. Panduit 1: Demand for the Patented Product

Proving demand for the patented product is generally straightforward when the infringement involves an arm’s length sale of the invention: an actual transaction with a willing buyer is the most direct evidence of demand. The main complication arises when the patented invention is but one component in a larger final product. For example, suppose that a car manufacturer patents a new taillight and installs it on all of its vehicles. This feature may be desirable but it is just one of many different attributes that consumers may consider before buying. Is there a measurable demand for the invention if the taillight patent is infringed? Company marketing documents are often a good source of information on the particular features that differentiate complex products and create demand. Accounting data can also be relevant, e.g., a large fraction of the total cost of final product that is due to the invention may be evidence for the requisite demand. When sufficient data exist, econometric models of demand can also help answer this question. But the cases show that proving the demand for a component of an assembly is likely to remain contentious.

Panduit (1) is also related to the legal doctrine known as the “entire market value rule.” This rule holds that when the sale of an entire assembly depends on a patented invention embodied in it, then damages may be based on the value of the entire assembly. If demand for the component can be proven, then the way is open for the entire market value rule to apply, as recently explained by the Federal Circuit in a case involving a patented fan sold in an assembly including a radiator and condenser: “Denso did not sell these assemblies without fans. Denso’s internal documents stress, moreover, that the performance and price of the entire system were paramount to its customers. This evidence amply supports the finding that the assemblies were a single functional unit. In addition, the evidence shows that customers wanted fans that were balanced to a certain specification and...the demand for the entire assembly depended on the patented invention....Thus, the jury properly applied the entire market value rule...”²⁸

²⁷ *Panduit Corp. v. Stahl Bros. Fibre Works, Inc.*, 575 F.2d 1152, 1156, 197 U.S.P.Q. (BNA) 726, 730 (6th Cir. 1978).

²⁸ *Tec Air v. Denso Mfg.* 192 F.3d 1353; 1362.

b. Panduit 2: Absence of Acceptable Substitutes

Panduit (2), the absence of acceptable non-infringing alternatives, has received the greatest amount of attention in subsequent cases and commentaries. Whether it scotches a lost profits claim largely depends on the interpretation of “acceptable.” If construed in engineering terms, there may be few or no alternatives that are technically similar to the patented invention. This would allow a claim to go forward. But there may be many economically acceptable alternatives to a given technical specification, depending on consumer preferences. This would block a great many plaintiffs. Interpretation of this factor therefore has great strategic importance.

If taken literally, Panduit (2) reads as a conservative position on damages. It states that a two-supplier market is a prerequisite for lost sales. A single non-infringing competitor with minimal market share would defeat all claims for lost sales. However, Panduit (2) implicitly takes the view that it is impossible to predict reliably the amount of the infringing sales that would go to the patent holder in this circumstance. However, since *State Industries v. Mor-Flo* this rule has been relaxed to reflect the reality that even if there is sizable non-infringing competition in the but-for market, the patent holder would still be likely to make at least some additional sales if the infringer were removed.

When the patented invention significantly differentiates a product in the eyes of consumers it is easier to find that there is no acceptable non-infringing alternative, thereby justifying the lost sales claim. That is, product differentiation could justify a narrow market that contains just the patent holder and the infringer. In practice, courts have considerable leeway in this regard, which only emphasizes the importance of the evidence on market definition.

c. Panduit 3: Manufacturing and Marketing Capability

The point of the third prong is to allow lost sales only when the patent holder is in a position to increase output to make additional sales. If the patent holder was capacity constrained then Panduit 3 would not allow lost sales. In a detailed analysis when capacity constraints come into play, it would be necessary to examine the cost of acquiring additional facilities and possibly also to examine whether existing licensees could have increased output to make some of the accused sales.

Moreover, if output would truly be restricted in the but-for market below the actual level, economics suggests that the but-for price would be higher, i.e., that price erosion should be part of the claim. Few cases focus on the third prong in any event, and the author is aware of none that make the connection to price erosion.

d. Panduit 4: The Patent Holder’s Profit

The fourth prong specifies the economically relevant accounting for the patent holder’s but-for profits. The accounting aspect of damages is not to be ignored, since the *Panduit* court described it as the “Achilles heel” of the plaintiff’s claim.²⁹ Specifically, Panduit improperly included some components of fixed costs when calculating its profit margin. The correct approach uses incremental profit, and it is doubtful that there are any valid exceptions to this

²⁹ *Panduit Corp. v. Stahlin Bros. Fibre Works, Inc.*, 575 F.2d 1152, 1156, 197 U.S.P.Q. (BNA) 726, 730 (6th Cir. 1978).

rule. The definitive statement on this point was made by the Federal Circuit in *Paper Converting*: “The incremental income approach to the computation of lost profits is well established in the law relating to patent damages....[F]ixed costs—those costs which do not vary with increases in production, such as management salaries, property taxes, and insurance—are excluded when determining profits.”³⁰ That is, profits have to be defined in terms of the *incremental* revenue to the patent holder minus the *incremental* costs. Costs that the patent holder would incur in both the actual and but-for markets are not incremental and should not be included.

Incremental profit per unit is often close to gross profit per unit that can be deduced from financial statements (gross profit includes depreciation, usually a fixed cost, and can reflect other differences). Gross profit is revenue minus direct costs, and is typically considerably higher than bottom line net income. Damages per unit are therefore likely to be considerably higher than net income per unit as well.

There are three major issues for the profit analysis. First, the patent holder’s cost accounting system may allocate fixed costs to the internal accounts that might be used to calculate incremental cost. These allocations must be removed. Second, fixed costs have to be defined with respect to time frame and output levels. For example, even direct labor may be treated as fixed in the short run if an existing shift is underutilized. In the sufficiently long run, however, all costs are variable so analysis may be required to determine which costs are truly incremental given the facts of the infringement. Third, certain costs may be different in the but-for market but the patent holder’s standard costing system may not track them directly. For example, advertising or warranty expenses may be lower in the absence of the illegal competition from the infringer. If but-for output is at a much higher level, the patent holder may incur additional expenses to increase capacity. Accounting and statistical analyses can be used to make the required adjustments.

4. The Market Share Rule for Lost Sales

Lost sales with Panduit (2) were radically modified with the Federal Circuit’s affirmation of “market share” damages in *State Industries v. Mor-Flo*.³¹ This decision broke new ground by allowing lost sales in a market with multiple but-for competitors. The change involved using market shares to allocate the infringing sales pro rata. That is, the market share rule was deemed sufficiently reliable to overcome the concern about avoiding speculative damages under Panduit (2).

The market share rule is fairly straightforward. Suppose in the actual market with infringement the infringer had a 20% share and the patent holder had a 40% share (generally calculated as a share of the total revenue in the relevant market). The patent holder therefore has a 50% share of the *non-infringing* sales (40% divided by 80% non-infringing share). On this basis, the patent holder is credited with 50% of the infringing sales.³² That is, the lost sales are a

³⁰ *Paper Converting Machine Co. v. Magna-Graphics Corp.*, 745 F.2d 11, 22; 223 U.S.P.Q. (BNA) 591

³¹ *State Indus. v. Mor-Flo Indus.*, 883 F.2d 1573, 1576, 12 U.S.P.Q.2d (BNA) 1026, 1027 (Fed. Cir. 1989), *aff’d*, 948 F.2d 1573, 20 U.S.P.Q.2d (BNA) 1738 (Fed. Cir. 1991).

³² The procedure that was actually used in *State Industries v. Mor-Flo* just used the patent holder’s share without adjustment, a calculation has been criticized by numerous commentators. However, the original formulation can be justified in certain

fraction of the infringing sales, where the fraction equals the patent holder's share divided by 1 minus the infringer's share. This is the pro-rata logic of the market share rule. Implicitly, the other but-for competitors would gain their corresponding share of the infringing sales as well. It can be seen that in a two-supplier market the market share rule allocates all of the infringing sales to the patent holder, as would be expected.

There are two economic preconditions for the market share rule to give reasonable results. First, a defensible market definition is needed in order to calculate economically meaningful shares in the first place. If relevant firms/products are left out then the patent holder's share, and lost sales, will be exaggerated. Conversely, if the market is overly broad (i.e., it includes non-infringing firms/products that do not compete with the patent holder) then lost sales will be understated.

Second, the characteristics of the goods in the market need to be such that market share can be plausibly interpreted in effect as the probability of the making an additional sale in the absence of the infringer. This assumption becomes harder to defend if the products in the relevant market are highly differentiated. Still, the market share rule is often a good starting point, especially compared to the alternative of assuming zero lost sales.³³ In this connection, it is appropriate to recall the legal principle that while damages may not be based on speculation, "they need not be proved with unerring precision, either."³⁴

Court decisions have clearly struggled with the issue of but-for competition. At present there do not seem to be hard and fast guidelines as to when Panduit (2) is used to rule out lost sales and when the market share rule is used to put them back in play. It turns out that the market share rule can be extended to allow a more flexible pattern of sales diversion than the simple pro rata method would indicate.³⁵ This is an important area where economic research is likely to provide useful contributions in the future.

5. Sales of Unpatented Products

Infringement damages can be awarded for sales that do not involve the patented product but there is a tension with the long-standing legal conservatism about extending the scope of the economic protection created by a patent. The entire market value rule discussed Section III(A)3(a) is one example where the value of unpatented components are brought within the ambit of the damages calculation. The legal standard for the entire market value rule to apply in essence requires the components to form "a single functional unit." With some modification, the Federal Circuit has also clarified how damages can be awarded for other types of non-infringing sales but this area still appears to be in a state of flux.

circumstances. See Roy J. Epstein, *State Industries and Economics: Rethinking Patent Infringement Damages*, 9 Fed. Cir. B.J. (2000) at 379.

³³ For a related economic perspective on the use of market share damages see Gregory J. Werden et al., *Economic Analysis of Lost Profits from Patent Infringement With and Without Noninfringing Substitutes*, 27 AIPLA Q.J. 305 (1999).

³⁴ *Minnesota Mining & Mfg. Co. v. Johnson & Johnson Orthopaedics, Inc.*, 976 F.2d 1559, 1579, 24 U.S.P.Q.2d (BNA) 1321, 1338 (Fed. Cir. 1992).

³⁵ The author has ongoing research in this area based on the market share "nesting" concept described in Roy J. Epstein & Daniel L. Rubinfeld, *Merger Simulation: A Simplified Approach with New Applications*, 69 ANTITRUST L.J. 895 (2002).

The most important recent decision in this context is *Rite-Hite*, which involved a patented device (the MDL-55) to prevent a truck from separating from its loading dock.³⁶ Damages were claimed for sales of two additional devices that ended up receiving different treatment by the court. First, Rite-Hite sold a more expensive alternative to the MDL-55 known as the ADL-100. The ADL-100 was also patented but there was no allegation of infringement of this patent. Instead, Rite-Hite argued that the infringing device was a particularly close substitute for the ADL-100 so that the lost sales primarily involved that product, although Rite-Hite claimed lost sales for the MDL-55 as well.

The Federal Circuit affirmed these damages by articulating the principle of “reasonable, objective foreseeability” discussed in Section III(A)(1). Specifically, “Rite-Hite's lost sales of the ADL-100, a product that directly competed with the infringing product, were reasonably foreseeable....Being responsible for lost sales of a competitive product is surely foreseeable....Such lost sales should therefore clearly be compensable.”³⁷ In economic terms, the court appeared to endorse the concept that all of the patent holder’s sales in the same relevant market are potentially harmed by infringement, regardless of the patent status of products other than the patented invention.

Rite-Hite’s sales of an unpatented “dock leveler” accessory for the MDL-55 and the ADL-100 were more controversial. Rite-Hite’s damages claim for the dock leveler was based on the entire market value rule.³⁸ While the district court permitted these damages, the Federal Circuit reversed, stating that there was no liability for other items sold with the infringing device “only as a matter of convenience or business advantage.” As an optional piece of equipment, the dock leveler did not meet the “single functional unit” criterion. Since it did not compete with the infringing item, it was not sold in the same relevant market either.

Economics is more receptive to claims like the dock leveler. Suppose, for example, that an expensive line of patented sunglasses also offered a matching and equally expensive, but unpatented, eye strap. Moreover, suppose that historically 80% of the patented sunglasses were sold with the matching strap and that the infringement deprived the patent holder of both sales. In economic terms, the glasses and the case are “complements.” The finding in *Rite-Hite* could well deny damages on the strap. However, these facts also seem consistent with “foreseeability” where 80% of the profits on straps would be an appropriate addition to damages to make the patent holder whole. This is another area where a market share rule could be fruitfully employed.

The “relevant market” logic of *Rite-Hite* was re-emphasized by the Federal Circuit in *King Instruments*.³⁹ Here King Instruments did not even make or sell its infringed invention, which related to loading magnetic tape into cassettes.. It was stated in Section III(A)(2) that when the infringer and the patent holder do not compete in the same market then the appropriate remedy is a reasonable royalty. The wrinkle in *King Instruments* is that the patent holder sold a

³⁶ *Rite-Hite Corp. v. Kelly Co.*, 56 F.3d 1538, 35 U.S.P.Q.2d (BNA) 1065, 1067 (Fed. Cir. 1995).

³⁷ 56 F.3d 1538, 1545, 1546, 35 U.S.P.Q.2d (BNA) 1065 (Fed. Cir. 1995) (en banc).

³⁸ 56 F.3d 1538, 1545, 1549, 35 U.S.P.Q.2d (BNA) 1065 (Fed. Cir. 1995) (en banc).

³⁹ *King Instruments Corporation v. Luciano Perego And Tapematic*, 65 F.3d 941; 36 U.S.P.Q.2D (BNA) 1129.

different, unfringed product in competition with the infringer. The Federal Circuit awarded lost sales.

King Instruments is also notable for affirming damages for lost future sales of spare parts. Relatively few cases award future damages due to the speculative nature of many sales forecasts but demand for spare parts may be a relatively predictable area. In addition, damages for spare parts seems like a move towards to the logic of awarding damages for complementary goods. While consistent in terms of economics, it remains to be seen how much further the courts are willing to head in this direction.

B. Price Erosion

Price erosion occurs when the infringement lowers the price on the units sold by the patent holder. That is, in the but-for market the patent holder would have been able to charge a higher price. The appellate decision in *Panduit* declared that “[t]he right to damages caused by price reduction stands on the same ground as that to damages caused by lost sales.”⁴⁰ Even small amounts of price erosion can result in large damages because the increased price generally is applied to the patent holder’s entire base of actual sales, as well as to the lost sales.

Economics predicts that price erosion should be endemic in patent infringement.⁴¹ But proving price erosion requires a degree of sophistication of economic analysis, the absence of which has historically limited the number and success rate of such cases. The intrinsic need for economics in this area seems clear: *Panduit* illustrates the confusion that can result otherwise. The special master found that the price erosion *benefited* the patent holder: “the price reduction resulted in a net increase in profit to the plaintiff.”⁴² This finding, which survived appeal, defies economic logic because if it were true the patent holder should have unilaterally reduced price absent the infringement, if price cutting was a profitable strategy.⁴³ With a growing number of new decisions to provide guidance it is likely that price erosion awards will become more familiar and more common in the future.

There are two parts to any price erosion claim. First is proving the amount of the price erosion. This can raise significant causation questions since defendants are certain to argue, as in *Yale Lock v. Sargent*, that “the competition of the defendant was not the sole cause of the reduction of the plaintiff’s prices.”⁴⁴ A dynamic market will always incorporate many factors into the price so the question becomes how to measure the separate effect of infringement. The main implication from economics is that regardless of the decline in prices due to other factors, the infringement tends to cause prices to be even *lower*.

⁴⁰ *Panduit Corp. v. Stahlin Bros. Fibre Works, Inc.*, 575 F.2d 1152, 1157, 197 U.S.P.Q. (BNA) 726, 730 (6th Cir. 1978).

⁴¹ *In re Mahurkar Double Lumen Hemodialysis Catheter Patent Litig.*, 831 F. Supp. 1354, 1387, 28 U.S.P.Q.2d (BNA) 1801, 1827 (N.D. Ill. 1993) (“Patents create a lawful ability to exclude competition, and thus some ability to increase price.”), *aff’d*, 71 F.3d 1573, 37 U.S.P.Q.2d (BNA) 1138 (Fed. Cir. 1995). See also Jonathan I. Arnold et al., *The Law and Economics of Reasonable Royalty Damages After Black & Decker’s ‘Snakelight’ Litigation*, 7 FED. CIR. B.J. 373 (1997).

⁴² *Panduit Corp. v. Stahlin Bros. Fibre Works, Inc.*, 575 F.2d 1152, 1157, 197 U.S.P.Q. (BNA) 726, 730 (6th Cir. 1978).

⁴³ See Roy J. Epstein, *State Industries and Economics: Rethinking Patent Infringement Damages*, 9 Fed. Cir. B.J. (2000) at 369.

⁴⁴ 117 U.S. 536, 551 (1886).

Recent cases demonstrate a variety of methods to prove the amount of price erosion. In *Brooktree v. Advanced Micro Devices* the court compared the price of the same product before the infringer entered the market and accepted testimony that the infringing competition forced the plaintiff to lower its prices to prevent losing business it had already developed.⁴⁵ In *Lam v. Johns-Manville Corp* there was evidence Lam reduced its prices on specific bids in response to the infringer's price-cutting.⁴⁶ In *Minnesota Mining & Manufacturing v. Johnson & Johnson Orthopaedics*, the court accepted comparisons with pre-infringement prices and also with the price trend for a related product not affected by the infringement.⁴⁷ The opinion in *Mahurkar* found that cost savings from the invention justified but-for prices that would have increased much faster than the actual prices.⁴⁸

The second issue with price erosion involves a fundamental economic principle: the higher but-for price implies a reduction in the quantity sold. This is often expressed in terms of a "price elasticity of demand," which measures the percentage reduction in quantity sold for a 1% price increase, all else equal. For example, an elasticity of -2 means that a 1% price increase is associated with a 2% quantity decrease. Because competitive conditions differ across markets, elasticities also differ across markets. Elasticity has been studied empirically in many different markets and the overwhelming evidence is that demand is responsive to changes in price, i.e., elasticity is not equal to zero.

The Federal Circuit recently made it clear in *Crystal Semiconductor* that a reliable analysis of price elasticity is an essential part of a price erosion claim. It explicitly acknowledged that "[a]ccording to basic tenets of economics, because Crystal is in a competitive market, if Crystal raised prices, Crystal's sales would have fallen."⁴⁹ The plaintiff's failure to account for this effect to the court's satisfaction resulted in the reversal of a \$26 million price award by the jury. Even if the amount of price erosion is measured with complete accuracy, faulty treatment of price elasticity effects will throw off the damages calculation. This logic also has an important corollary for the two-supplier market—with price erosion the patent holder should *not* be presumed to make all of the infringer's unit sales.

Suppose, for example, that in a market for widgets a patent holder sold 800 units and an infringer, the sole competitor, sold 200 units and that the actual price was \$10. The patent holder therefore had revenue of \$8,000, the infringer had revenue of \$2,000, and the total market size was \$10,000. Assume the infringement caused 10% price erosion (i.e., in the but-for market the patent holder would have charged \$11) and that there was 40% profit margin on each actual sale. An erroneous damages calculation that ignored elasticity might proceed as follows: 10% price erosion times \$10,000 total market revenue (\$1,000) plus the product of 40% profit margin times \$2,000 "lost" sales (\$800) equals \$1,800 total lost profits. The problem is, due to elasticity, the

⁴⁵ *Brooktree Corp. v. Advanced Micro Devices, Inc.*, 977 F.2d 1555, 1579, 24 U.S.P.Q.2d (BNA) 1401, 1418 (Fed. Cir. 1992).

⁴⁶ *Lam, Inc. v. Johns-Manville Corp.*, 219 U.S.P.Q. (BNA) 599, 600 (D. Colo. 1982).

⁴⁷ *Minnesota Mining & Mfg. Co. v. Johnson & Johnson Orthopaedics, Inc.*, 976 F.2d 1559, 1579, 24 U.S.P.Q.2d (BNA) 1321, 1338 (Fed. Cir. 1992).

⁴⁸ *In re Mahurkar Double Lumen Hemodialysis Catheter Patent Litig.*, 831 F. Supp. 1354, 1389, 28 U.S.P.Q.2d (BNA) 1801, 1829 (N.D. Ill. 1993), *aff'd*, 71 F.3d 1573, 37 U.S.P.Q.2d (BNA) 1138 (Fed. Cir. 1995).

⁴⁹ See *Crystal Semiconductor*, 246 F.3d 1336, 57 U.S.P.Q.2d (BNA) 1953.

higher but-for price would not allow the patent holder to sell the 1,000 widgets that underlie this calculation.

Which sales should be included in a price erosion calculation can require analysis. When there is no price discrimination, the usual procedure would include all of the patent holder's but-for sales (i.e., actual sales plus lost sales minus the adjustment for price elasticity). Price discrimination, particularly in the form of sales made pursuant to a bidding process, may justify using a considerably smaller base of sales. For example, if the patent holder targeted a price cut only on job A (perhaps because it was known that the infringer would not be competing for job B), then only job A may give rise to damages.

In sum, economic considerations suggest that price erosion should be a common occurrence in patent infringement. It requires additional inquiry to determine the amount of the price reduction. Moreover, such a claim requires credible evidence on the magnitude of the relevant price elasticity to adjust the lost sales. The elasticity adjustment can be relatively small or large, depending on the nature of competition in the relevant market. Fortunately, econometric tools are available help make these determinations empirically.⁵⁰

IV. RECENT ADVANCES IN THE ECONOMIC ANALYSIS OF PATENT DAMAGES

The developments in economic analysis described in this section were motivated by some of the most important unsettled patent damages issues confronting legal practitioners discussed above. These developments are intended to be applicable to real-world case law, using data likely to be available in the normal course of patent litigation. Moreover, they combine rigorous economic underpinnings with a high degree of transparency to promote clarity of analysis.

The discussion includes four specific areas:

- Determination of a reasonable royalty based on corporate finance principles;
- Calculation of lost profits with price erosion based on *Crystal Semiconductor*;
- Measurement of price erosion using the economic theory of demand;
- Use of the split award when price erosion damages are also awarded.

The description of each method is necessarily brief, cites are provided to published articles that offer greater detail.

A. FIRRM—Financial Indicative Running Royalty Model

Cases since *Georgia-Pacific* highlight the difficulties of determining a credible reasonable royalty. The norm of highly divergent plaintiff and defendant claims led the Federal Circuit to conclude recently in *SmithKline Diagnostics v. Helena* that a court “may reject the extreme figures proffered by the litigants as *incredible* and substitute an intermediate figure as a

⁵⁰ See, e.g., Jonathan B. Baker & Daniel L. Rubinfeld, *Empirical Methods in Antitrust Litigation: Review and Critique*, 1 AM. L. AND ECON. REV. 386 (1999).

matter of its judgment.”⁵¹ (emphasis added) What has been lacking is a simple, coherent method for updating the insights of the Georgia-Pacific factors with a modern economic analysis.

The author recently developed a new royalty approach that uses basic principles of corporate finance to calculate a reasonable royalty.⁵² The approach, called FIRRM (“Financial Indicative Running Royalty Model”), builds on the Georgia-Pacific foundation and reflects the logic of the leading subsequent decisions. It is designed to be tractable and to exploit the *ex ante* financial information likely to be available in a patent infringement case. FIRRM provides an economically rational alternative to the 25% (of profits) and 5% (of revenue) rules. It should also be superior to royalties from surveys in which the deals surveyed are often not comparable to the case at hand.

FIRRM is based on two key economic ideas to quantify an *ex ante* royalty. First, the profits from the infringing activity have to be compared to the profits from the infringer’s “next-best” alternative project at the time of the hypothetical negotiation. The maximum willingness to pay for the relevant patent rights would then depend on the profitability of the alternative project as a “replacement” for the infringing activity.⁵³ The alternative could include licensing a substitute technology or designing around the patent. An alternative project that was nearly as profitable implies that a negotiation would result in only a low royalty. Lower value alternatives imply higher reasonable royalties. Whatever the best alternative would be, it establishes the profit the infringer could have expected to earn absent the infringement.

The second key element is the need for the infringer to earn a minimum expected return, without which the investment would not be undertaken. This minimum return is defined in corporate finance as the “cost of capital.” The project must have a return at least equal to the cost of capital or investors will commit their capital elsewhere.⁵⁴ The reasonable royalty, absent punitive damages, should be no higher than the level that is expected to allow the infringer to earn the cost of capital or the hypothetical royalty negotiation would not be successful. Even when the infringer has no other explicit alternative, the cost of capital still sets an upper bound on the royalty.

The difference in profits between the infringing project and the alternative is the basis for the reasonable royalty generated by FIRRM. For example, suppose the infringing project has expected profits of \$10 million. The next best alternative does not infringe but would yield profits of only \$9 million. In a hypothetical royalty negotiation, the infringer would be willing to pay a royalty of at most \$1 million (either as a single up-front payment or as a running royalty on future sales with an equivalent present value). The ability of the patent holder to extract value

⁵¹ *SmithKline Diagnostics, Inc. v. Helena Laboratories Corp.*, 926 F.2d 1168.

⁵² Roy J. Epstein and Alan J. Marcus, *Economic Analysis of the Reasonable Royalty: Simplification and Extension of the Georgia-Pacific Factors*, 85 JPTOS (July 2003).

⁵³ Compare Marcus Finnegan and Herbert Mintz, “The Determination of Reasonable Royalty” in *The Law and Business of Patent and Know-How Licensing* 6th edition, edited by Brian G. Brunsvold and Dennis P. O’Reilly at I-8: “The maximum royalty that would normally be reasonable for a licensee to pay is that which is less than the cost of the next best alternative available to the licensee.”

⁵⁴ For a detailed discussion of the calculation of the cost of capital and related issues see Richard A. Brealey, Stewart C. Myers, and Alan J. Marcus, *Fundamentals of Corporate Finance* 2001 at 317.

through the royalty is limited by the value of the infringer's alternative investment and the cost of capital.

FIRRM has a relatively simple structure but it incorporates the most important financial features that are useful in evaluating the ex ante profitability of the infringer and, by extension, the reasonable royalty. Mathematically, it is an application of standard present value analysis in corporate finance. FIRRM derives the royalty in terms of the duration of the investment project, the remaining life of the patent, the infringer's cost of capital, the internal rate of return of the infringing project, and the ratio of the net present value of the alternative project to the net present value of the infringing project.

The district court decision in *SmithKline Diagnostics v. Helena* contains sufficient data to provide a good example of FIRRM. The model yields a royalty from 23.7% to 36.5%. The actual award of a 25% royalty is within this range. The infringer's proposed 3% royalty would require a marked difference in assumptions that would require justification. FIRRM also indicates that, without additional information, the plaintiff's proposed royalty of 48% is also extreme. On balance, FIRRM greatly narrows the plausible range for the royalty and suggests that the court reached an economically defensible outcome.

B. PERLS — Price Erosion and Lost Sales with the Market Share Rule

The Federal Circuit ruled in *Crystal* that lost sales damages had to be reconciled with the effects of price elasticity when there was also a claim of price erosion. That is, one cannot assume that but-for the infringement, the patent holder would have reaped the benefits of both higher prices and the same number of sales. The court went on to say that it would refuse "to evaluate price erosion and lost profits damages separately."⁵⁵ This analysis therefore warns that a unified methodology is needed but it does not explain how to reach an economically consistent result.

The author recently published an economic model called PERLS (Price Erosion and Lost Sales) that integrates lost sales with the effects of price erosion to meet the analytical requirements set forth in *Crystal*.⁵⁶ PERLS is firmly grounded on the market share rule: as in the case of zero price erosion, the patent holder's but-for share equals its actual share divided by 1 minus the infringer's share. The innovation is that the patent holder's but-for sales contain an explicit adjustment for price elasticity. PERLS provides an economically coherent framework to integrate these elements into a single calculation.

PERLS takes the form of an algebraic expression that relates total lost profits to the patent holder's actual revenue and incremental profit margin, the amount of the price erosion, the infringer's market share, and the magnitude of the price elasticity. All of these components can be measured empirically, making the calculation reasonably transparent. When the price erosion is zero, the expression reduces to the conventional market share damages calculation described in section III(A)4.

⁵⁵ *Crystal Semiconductor* at 1361.

⁵⁶ Roy J. Epstein, *The Market Share Rule With Price Erosion: Patent Infringement Lost Profits Damages After Crystal*, 31 AIPLA Q.J. 1.

PERLS is most easily illustrated with an example. Suppose the market data are the following. The total market size is \$120 million. The patent holder has a 60% market share, the infringer has a 25% market share, and non-infringing alternatives account for the remainder. The patent holder therefore has sales of \$72 million and the infringer has sales of \$30 million. The patent holder has a 40% incremental profit margin (price minus incremental cost, divided by price) in the market with infringement. Finally, suppose there was price erosion, so that the but-for price for the patent holder would be 10% higher. Since there is price erosion, the analysis must account for price elasticity. Assume the elasticity has a value of -1.5 .

PERLS in this case yields integrated lost sales and price erosion damages of \$12.7 million. If elasticity were ignored (the problem that preoccupied the *Crystal* court) the calculation would yield \$19.2 million. That is, failure to account for elasticity would overstate damages by over 50% in this example. If price erosion were disallowed (i.e., set to zero), damages would fall to \$9.6 million, the value corresponding to an award only of lost sales. Price erosion increases damages above the lost sales base amount but elasticity limits the additional damages.

The value of PERLS becomes apparent in practice when considering the lost profits claims asserted in *Crystal*. The plaintiff claimed \$14.3 million lost sales damages and \$34.7 million price erosion (about 10%), for \$49 million in total lost profits. The defendant calculated \$7.4 million in lost sales damages and zero price erosion. The jury awarded \$11.8 million lost sales damages and \$26.6 million price erosion (about 7.7%) for \$38.4 million in total lost profits.

The PERLS analysis shows that the plaintiff claim and the jury award implicitly assume a substantially “inelastic” demand, with a value for the price elasticity of approximately -0.5 . This is a key assumption that should be supported by additional evidence. Using an alternative value of -1 for the elasticity, a value often used by economists, would reduce the calculated damages considerably: the plaintiff claim would drop to \$35.2 million and the jury award would drop to \$28 million.⁵⁷ The elasticity effect would also compound the additional adjustment that would be required if different assumptions were made about the amount of price erosion.

C. Economic Model for Amount of Price Erosion

Section III(B) above discussed a number of methods that have been used to determine the amount of price erosion. When the market share rule applies to the but-for market then the economic theory of demand provides an alternative approach. It results in a formula for price erosion that requires only the incremental profit margin for the patent holder, the infringer’s share, the patent holder’s share, and the market price elasticity, information that should be readily available.⁵⁸ The advantage of the formula is that it can be easily implemented in a wide range of circumstances with a minimum of data. The theory of demand complements the other approaches and serves as an independent, transparent, and economically consistent benchmark. The formula therefore offers significant additional potential for ensuring the reliability of price erosion analyses.

⁵⁷ For further discussion of PERLS and *Crystal*, see Roy J. Epstein, *The Market Share Rule With Price Erosion: Patent Infringement Lost Profits Damages After Crystal*, 31 AIPLA Q.J. at 36.

⁵⁸ This formula is explained in detail in Roy J. Epstein, *The Market Share Rule With Price Erosion: Patent Infringement Lost Profits Damages After Crystal*, 31 AIPLA Q.J. at 46.

There is an important special case of the model that applies when the price elasticity equals -1 and the infringement has no effect on the patent holder's costs. The model states in this case that price erosion takes a simple form:

$$\text{price erosion} = \text{patent holder's profit margin \%} \times \frac{\text{infringer's market share}}{1 - \text{infringer's market share}}$$

This formula indicates that a higher patent holder profit margin increases the predicted price erosion (i.e., there is greater scope for price competition). Price erosion also rises with increases in the infringer's share, i.e., the market success of the infringement. While other factors may cause falling prices during the infringement, the analysis identifies a separate role for the infringement, with the implication that in the but-for market prices would not have fallen as much or would have risen instead.

As an example of the calculation with unitary elasticity, suppose that the patent holder had a 40% incremental profit margin and that the infringer had a 20% market share. The formula predicts 10% price erosion (40% times 20% divided by 80%). This value could then be considered in conjunction with other evidence in the case. While simple, it again underscores the importance of accurate measurement of the profit margin and market shares. A market share of only 10% for the infringer, for example, would lower the predicted price erosion to 4.4%.

*Minnesota Mining & Manufacturing v. Johnson & Johnson Orthopaedics*⁵⁹ provides a striking comparison of the price erosion formula to other approaches. This case involved damages for infringement in a market for orthopedic casting tapes. Though not explicitly stated, it can be deduced from the special master's opinion that the court awarded 13.3% average price erosion. The special master's opinion on damages was impressive for its grasp of the economic issues but it was highly complex. It invites use of the price erosion formula as a separate reality check.

Other information in the opinion indicates a profit margin for the patent holder 3M of approximately 41.1% and an average share for the infringer JJO over the damages period of about 24.3%. This is enough information to use the price erosion formula (assuming elasticity of -1 and no changes in cost). The predicted effect is 13.2%, almost exactly the conclusion of the court. The formula therefore appears to convey about the same amount of economic information as the opinion's lengthy discussion of trends in 3M's prices and industry producer price indexes, as well as different degrees of competitiveness of the infringer and the other firms in the market.

D. Critique of the Split Award

The "market share" methodology introduced in *State Industries* actually makes two kinds of damages awards. First, the patent holder is credited with a fraction of the infringing sales according to its market share. For the remaining infringing sales in the same market, the patent holder receives a reasonable royalty. The logic of *State Industries* therefore treats each infringing sale in the relevant market as either a lost sale for the patent holder or a basis for a royalty payment. Combining lost sales and a reasonable royalty in this way is known as a "split award."

⁵⁹ 1991 U.S. Dist. LEXIS 11451 (D. Minn. Apr. 30 1991), *aff'd*, 976 F.2d 1559, 24 U.S.P.Q.2d (BNA) 1321 (Fed. Cir. 1992).

The split award probably is not appropriate when there is also a price erosion award. The lost profits calculation is already supposed to make the patent holder whole, and an additional royalty is likely to result in overcompensation. Economically, the split award seems more justifiable as a rough substitute for a “missing” price erosion claim but it is not necessary when price erosion is properly accounted for. Moreover, it can lead to a confusing analysis because lost profits are calculated *ex post* and the reasonable royalty is framed *ex ante*. As discussed in Sections III(B) and IV(C), economics has a great deal to offer regarding the measurement of price erosion and such an analysis can certainly be as reliable as the “legal fiction”⁶⁰ that has often characterized reasonable royalty rates.

The Federal Circuit did not face this issue in *Crystal* because it disallowed price erosion. In the end, the case was resolved with a conventional split award (plus enhanced damages). In future price erosion cases, however, there is a strong justification to exclude reasonable royalty damages.

V. CONCLUSION

There has been substantial progress in recent years in the analysis of lost profits damages and reasonable royalties in patent infringement. Decisions by the Federal Circuit and other courts have extended the key insights of the two fundamental cases, *Georgia-Pacific* and *Panduit*, and made them more consistent with basic economic principles. At present, the reasonable royalty is most in need of overhaul. *SmithKline Diagnostics v. Helena*, while several years old, still stands as a warning that Georgia-Pacific factors are too susceptible to extreme and even “incredible” outcomes. The most important decisions relevant to lost profits discuss the market share rule for lost sales (*State Industries v. Mor-Flo*), market definition (*BIC Leisure v. Windsurfing*), sales of unpatented goods (*Rite-Hite v. Kelley*; *King Instruments v. Perego*), and the need to account for price elasticity in price erosion claims (*Crystal Semiconductor v. Tritech*). These decisions have improved damages analyses considerably but there is scope for further refinement of the basic approaches.

Recent scholarly work on the interface of economics and law has identified a number of promising contributions to improve the analysis of infringement damages. The author has developed an implementation of the market share rule that yields economically consistent damages when price erosion is asserted. His model, denoted PERLS (“Price Erosion and Lost Sales”), incorporates an explicit adjustment for price elasticity effects. He has also developed a simple formula based on the economic theory of demand to predict the amount of price erosion in a patent infringement. This formula has worked well to “reverse engineer” some of the more important price erosion decisions, indicating its value in simplifying the analysis of price erosion and making it more transparent. Finally, in regard to market share damages with price erosion, the author has found that it is inappropriate to add additional damages in the form of a reasonable royalty for the remaining infringing sales in the same market. That is, the split award should not be used when there is price erosion.

⁶⁰ *Panduit Corp. v. Stahl Bros. Fibre Works, Inc.*, 575 F.2d 1152, 1159, 197 U.S.P.Q (BNA) 726, 732 (6th Cir. 1978). (“Determination of a ‘reasonable royalty’ after infringement, like many devices in the law, rests on a legal fiction...the ‘reasonable royalty’ device conjures a ‘willing’ licensor and licensee, who like Ghosts of Christmas Past, are dimly seen as ‘negotiating’ a ‘license.’”)

The author has also developed a tractable financial model to analyze the reasonable royalty using a conventional corporate finance framework. This model, denoted FIRRM (“Financial Indicative Running Royalty Model”), takes account of the key financial variables that determine the expected profitability of the infringement. It yields a royalty that increases with the profitability of the infringing activity, but allows the infringer a reasonable profit in the sense that the infringer at least earns the appropriate cost of capital. This framework provides a coherent and transparent way to update the insights of the Georgia-Pacific factors using modern economics. FIRRM is likely to be more reliable than common alternatives such as the 25% and 5% rules and royalty rates gleaned from surveys and marketing databases.

These analytical developments are part of a continuing effort to place damages analysis on a footing that is satisfactory to both the demands of the law and the laws of economics. They should help focus the parties on the key facts and data relevant for measuring damages and lead to more efficient resolution of patent infringement cases.