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**FORENSIC ECONOMICS:  
AN INTRODUCTION  
WITH SPECIAL EMPHASIS ON PRICE FIXING**

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## INTRODUCTION

I define forensic economics as economic analysis delivered to government authorities in public places. Here, “government” is construed broadly as administrative agencies, regulatory commissions, and judicial bodies.

Apart from the occasional best seller, economical writing is directed mainly to other professional economists, eschews emotive language, has little market value, avoids the appearance of taking sides in policy disputes, and is read only out of scientific curiosity. Forensic analyses, on the other hand, are scientific documents written for amateurs, made but not owned by their creators, based on reason but attention to rhetorical flair, are openly adversarial, and intensely read by a small circle of parties with often large income-transfers at risk.

The adjective “forensic” is derived from the Roman Latin word *forum*. The Roman Forum was the central location for Senatorial oration to the citizens and for the witnessing of contracts. The Forum became emblematic of the structure of ancient civil law. Forensic products – whether delivered orally or in writing – are prepared at the behest of a client and generally support the client’s interest. Forensic analyses are public in the sense that they are prepared with the expectation that they will be subject to scrutiny and rebuttal by the client’s opponent, and it is often the case that that debate will be carried on in a public setting or be made publicly available later. For that reason, forensic expert opinions are highly strategic documents prepared with an eye to anticipating the opponent’s arguments. They are rhetorical in the best Aristotelian sense of that term, and they are in a curious sense peer-reviewed.

In this paper I aim to explain accepted methods of forensic analysis and how forensic economics is used in the context of competition-law enforcement.<sup>1</sup> I will illustrate forensic analysis using examples from antitrust cases involving price fixing.<sup>2</sup>

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<sup>1</sup> Other settings for forensic economics are rate-setting commissions, environmental impact studies, international dumping disputes, inflation controls

<sup>2</sup> Fisher (2006) complements this paper by focusing on applications to monopolization and merger cases.

## BACKGROUND

### Ancient

Forensic economics may be as old a profession as prostitution is alleged to be.

In written history it goes back to at least 326 BC (Kotsiris 1988). In that year in Athens a public jury trial was held to convict a collusive ring of wholesale grain dealers (*emporoi*). As a city-state highly dependent on imports, Athenian grain laws were serious business. The case was based on laws instituted 150 years previously that aimed at preventing monopolization of the grain market. The law placed upper limits on the quantity a dealer could store and on the maximum mark-up.<sup>3</sup> Detection of price fixing was aided by *sycophants*, informers who received bounties if those they denounced to the Board of Grain Superintendents were successfully prosecuted at trial. During 324-326, military disturbances had caused prices to be especially volatile, and the grain dealers had formed a trade association that was used to bid collusively on purchases from importers and to restrict sales during periods of scarcity thereby generating monopsony and inventory profits.

The history of this trial is preserved by the fact that the prosecutor's oratory was written by Lysias, considered of the greatest orators of Athen's Golden Age. Of course there was no testimony by economists at the trial, but the prosecutor's speech is laced with economic reasoning. In Kotsiris' summary of one passage:

"The [prosecutor] anticipates the defendants' contention based on compensation or 'resistance' (*antistases*), namely that they infringed on the law in good faith in order to keep the prices down and to sell the grain to the people at the cheapest price. Such a contention cannot be sustained: because the grain dealers were charging six times the legal profit; because it is known that the grain dealers avoid contributing to common burdens when a special levy is needed, making poverty their pretext; because of the impudent rapacity of the grain dealers who trade on the misfortunes of the city. The [prosecutor] now emphasizes this point: in bad times the grain dealers store the grain and refuse to sell it so that the people are glad if they can purchase at any price however high, 'and thus in times of peace they become our besiegers.'"

Note that, if the prosecutor is correct in his facts (which the grain dealers had admitted), the ring's monopoly profits increased 500%.<sup>4</sup> The Athenian prosecutor goes on to evoke the principle of general deterrence to sway the jury:

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<sup>3</sup> The maximum grain inventory allowed was about 72 bushels (82 liters) and the maximum mark-up on cost was 0.18 drachmas per bushel (at a time when one drachma was a day's pay for a carpenter, stone cutter, or Senator).

<sup>4</sup> Prices probably increased by 20 to 50%.

“...[C]onviction is needed not only for what they have done but also as an example for the future, because in their business many prefer to risk their own lives every day than cease to gain illicit profits.”

*Plus ca change, plus ca même chose.* These are some of the same arguments that were raised in a well known antitrust trial in Chicago that convicted three officers of Archer Daniels Midland Company for their role in the lysine cartel (Connor 2001: Chapter 15). These three received close to the maximum prison sentences under U.S. antitrust law, whereas the Athenian bid riggers paid with their lives. How's *that* for deterrence?

## **Modern**

Now to bring the discussion up to modern times, my survey of the early cartels literature led me to read the works of Jeremiah W. Jenks (Connor 2006: Appendix).<sup>5</sup> He was Professor of Political Science at Cornell University in 1900 when the first of the five editions of his book *The Trust Problem* was published, though he had already been researching pools, trusts, and monopolies for 20 years by that time. Jenk's 1888 study of the Michigan salt cartel seems to be the first economic study of cartels to appear in a peer-reviewed English-language professional journal.

Jenks' publications display a strong empirical bent and show a deep interest in gauging the economic effects of cartels. Unusual among academics of the time, his commitment to the study of trusts seems to have been cemented by his extensive work as an advisor for the U.S. Industrial Commission, which held a series of public hearings in 1898-1899 on conditions in several oligopolistic industries. His books contain carefully constructed series of wholesale prices for refined sugar, whiskey, wire nails, barbed wire, steel, and other products controlled by cartels or dominant firms in late 19<sup>th</sup> century America. Among his analytical advances was the creation of coterminous price series for the principal inputs for the final products (corn for whiskey, steel for nails, etc.). Jenks seems to be the originator of the cost-based method of calculating overcharges. By correcting for changes in product prices due to input prices, he was able to determine more precisely when and how strongly prices were affected by a cartel.

What is interesting about Jenks is his drive to improve methods for calculating cartel overcharges and the fact that he used his experience as a forensic economist to chose topics of policy relevance. This is a theme often echoed by economists with forensic experience (e.g., Scherer 1999, Houthakker 1999), and it has been my personal experience as well.

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<sup>5</sup> Many academics who would now be called economists professed "Political economy," and until U.S. economics journals got started around 1890, many published in journals of political science.

The Sherman Act became law in July 1890, and Judge (and future President and Chief Justice of the Supreme Court) William Howard Taft wrote the first significant U.S. anti-cartel decision in 1898.<sup>6</sup> The *Addyston Pipe & Steel (1898)* case involved manufacturers of heavy cast-iron water and sewage pipes in the South and Midwest of the United States that rigged bids to local governments. Judge Taft's decision is a remarkably solid, quantitative empirical analysis of a naked bid-rigging conspiracy.

Taft used what has come to be known as the "yardstick method" in his discussion of the effects of the cartel. He chose to compare the cartel's prices with prices in the more heavily industrialized and competitive Northeast. As far as is known, economists played no role in either of these path-breaking decisions. The first citation to an economist's work by the Supreme Court is in a 1925 antitrust decision (Kovacic and Shapiro 2000: 47).

In 1914, in the Act authorizing the Federal Trade Commission, the U.S. Congress specifically required the FTC maintain a Bureau of Economics and endowed it with special data-gathering powers to carry on industry studies. This unit was small until the 1960s but its foundation is apparently the first government recognition of the value of forensic economics.<sup>7</sup>

## The Contemporary Scene

The role played by economic analysis in antitrust policy-making, public-agency prosecutions, and private litigation has greatly expanded in the last 30 years or so (Einhorn 1993, Coate and Klein 1996). Economists have had strong influence on antitrust enforcement since the mid-1970s. "Chicago School" ideas and the "New IO" movement affected the merger, vertical power, and price discrimination areas, but attitudes toward price-fixing did not alter very much if at all (Shepherd 2000). The major change in thinking may have been the issue of whether much observed collusion is achieved tacitly and the role of facilitating practices in collusion (and therefore putatively legally) (Hay 2000, Gertner and Rosenfield 1998). In the early 1990s the Supreme Court began to cite economics research on game theory to decide conscious parallelism cases. Perhaps the greatest contribution of economics to cartel policies was the use of game-theoretic concepts in the design of the DOJ's revised 1993 Corporate Leniency Program (Kovacic and Shapiro 2000).

The Antitrust Division of the U.S. Department of Justice (DOJ), because of its unique authority to prosecute criminal antitrust violations, is the primary agency responsible for federal anticartel enforcement. Since the late 1930s the DOJ has aggressively pursued hard-core cartels as serious, *per se*, criminal acts. In the

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<sup>6</sup> It was not until 1927 in *Trenton Potteries* that the Supreme Court made a definitive ruling making price fixing *per se* illegal.

<sup>7</sup> Many of the Bureau of Economics' studies are classics of their type, but few deal with naked cartels.

1940s it extended its domestic anticartel campaign to scores of prosecutions of international cartels (Wells 2002).

This international campaign, after a hiatus of 50 years, returned with a vengeance in the 1990s, as symbolized by its signal victory over the global lysine cartel in 1996 (Connor 2001). Until 1996 the DOJ had regularly failed to convict most of its international-cartel indictments because of concerns about comity (e.g., *Uranium*) or because of failures to summon key witnesses or subpoena inculpatory documents outside U.S. territory (*Industrial Diamonds*). At the same time, beginning in the mid 1970s other vertical and horizontal restraints began to be treated by the DOJ and the courts under a rule of reason analysis (Kovacic and Shapiro (2000: 53-54). Economists were first embedded in the DOJ in the 1970s and now comprise about 10% of the Antitrust Division's professional resources (ITN 2005). The DOJ and FTC regularly hire outside economists as consultants on specific cases.<sup>8</sup>

In the prosecution of cartels with sufficient evidence of an explicit agreement, the *per se* rule implies that the role of economic analysis will be limited to three tasks. First, if the appropriate fine mandated by the U.S. Sentencing Guidelines<sup>9</sup> exceeds the statutory limit of the Sherman Act,<sup>10</sup> then the DOJ must employ an "alternative sentencing statute" to calculate the fines (Connor and Lande 2005). The alternative fines are calculated using a double damages rule.<sup>11</sup> Therefore, forensic economists on the DOJ staff must prepare rough estimates of the overcharge as a basis for negotiating the fine with the alleged perpetrator prior to a guilty-plea agreement. These estimates have been published in a few sentencing memorandums that can be seen on the DOJ's web site ([www.usdoj.gov](http://www.usdoj.gov)).

Second, if a criminal trial is held, defendants will usually engage economists as advisors to provide arguments as to the ineffectiveness of the cartel. Even though evidence on the issue should be irrelevant, defense counsel will try to sow doubt about price effects in the jury. When only circumstantial evidence of an agreement is available, the testimony of economists may be needed to assist a jury in inferring the existence of an explicit agreement.

Third, after guilt at trial has been determined, the prosecution moves to a concluding second phase for sentencing. The government may opt to seek higher fines under the alternative sentencing statute. If so, the size of the monopoly overcharge or dead-weight losses will require economic opinions to guide the jury or presiding judge. The first time that the DOJ sought such elevated fines was in 1999 at the conclusion of the criminal proceedings against three individuals involved in the lysine cartel (*United States v. Michael D. Andreas et al.*) (Connor 2001: 434-440). In 2002, the owner of the art-auction

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<sup>8</sup> In the spirit of full disclosure, I have been a consultant to both agencies on cartel and merger cases.

house Christie's, billionaire A. Alfred Taubman, was required to pay a fine of \$7.5 million for his leading role in the cartel created with Sotheby's.

The vast majority of resources of forensic economists are expended in private antitrust suits. Consulting economists have been witnesses in antitrust trials since at least 1920, but commonly only since the 1960s (Kwoka and White 1994). Scherer's (1999:129) memoir relates that his first job as a forensic economist came in the late 1950s as an assistant to Harvard economist M.J. Peck in a collusion case in the tetracycline market. The first journal articles explaining some of the methods used by economists in litigation appeared in the late 1970s (Harris and Sullivan 1979, Fisher 1980). Finkelstein and Levenbach (1983) contained a critical review of regression estimates used in private antitrust cases in the late 1970s. Thus, somewhere in the 1960s or 1970s, forensic economics took off in the United States.<sup>12</sup>

There are about 1000 to 2000 private antitrust suits filed each year in the U.S. federal court system, plus an unknown number of suits in state courts. Private damages suits almost invariably require the services of forensic economists experienced in antitrust legal proceedings. Essays by forensic economists demonstrate the wide array of techniques employed to solve concrete legal questions, the stimulation that law cases provide for new research projects,<sup>13</sup> and the satisfaction that arises from influencing high-stakes legal battles (Slottje 1999). Forensic economics has heuristic value. One of the largest-selling books on law and economics consists almost entirely of chapters written from experiences by forensic economists (Kwoka and White 2004).

Many are academics or solo practitioners, but recent decades have seen the rise of large economic consulting firms that specialize in regulatory or antitrust matters. One of the largest and best known is LECG (formerly Legal Economic Consulting Group), which is now a publicly traded company. In 2004 LECG had revenues of \$246 million, and since 2000 its sales had grown by 83% per annum.<sup>14</sup>

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<sup>9</sup> The Guidelines have been in force since 1987 and are revised almost annually by the U.S. Sentencing Commission. In early 2005, a ruling by the Supreme Court relegated the Guidelines to advisory only, but it appears that most judges are still following the Guidelines closely.

<sup>10</sup> From 1990 to 2004, the corporate limit was \$10 million and the individual maximum was \$350,000 (Connor 2006). In mid 2004, the limits were raised to \$100 million and \$1 million, respectively.

<sup>11</sup> This rule is used under U.S. federal law for all economic crimes that are felonies, not just antitrust infractions.

<sup>12</sup> Fisher's (2006) claim to have been present at the creation around 1970 seems a bit late.

<sup>13</sup> I can testify to the power of forensic work to drive one's research. My 2001 book and papers cited therein were a direct result of my involvement in a civil and a criminal cartel case. A more recent research project published as Connor (2005) was a consequence of a disputed issue that arose in a 1999-2005 cartel case. I also believe that forensic experiences make for livelier teaching.

<sup>14</sup> Its Chairman David J. Teece was paid a salary of \$3.7 million.

In treble-damages class-action cases, the role of forensic economists is often crucial to two issues. The first is class certification, a hearing that requires the plaintiffs to prove that a number of legal conditions are satisfied. The economist's role at this stage is to offer a "formula" or method that can reasonably be expected to produce a reliable estimate of class-wide damages. Second, if class-action status is granted, the size of injuries becomes the main issue to be decided or negotiated. The limited sophistication of juries or non-specialist judges will put a premium on simple analytical approaches and on the persuasive skills of testifying experts. As discussed below, while more advanced theoretical or empirical points will often be presented in expert opinions, these exercises will often serve only to confirm opinions reached by simpler means or to neutralize the weight of the evidence presented by the other side during trials or negotiated settlements. Well over 90% of all private treble-damages cases filed are terminated by settlements.

Forensic economics is a recognized specialty area of economics. The *Journal of Forensic Economics* began publishing in 1987.

### **Ethical Considerations**

Forensic scientists sometimes develop reputations not dissimilar to soldiers of fortune, particularly medical experts testifying in person-injury cases. There is a great temptation for expert witnesses to become advocates for their clients' interests that may involve a loss of scientific objectivity (McKie-Mason and Pfau 1999). Lawyer-clients often make it clear what answer they expect to get from their experts. Plaintiffs' counsel want a large overcharge figure, and defendants' counsel want a small one.<sup>15</sup> The first time such a suggestion arises, an expert needs to remind the client that the economist's first duty is to offer an independent opinion to the fact-finder. Thereafter, the expert ought to educate the client on why the chosen method and outcome is the most appropriate. In the end it is simple professional integrity that dictates an appropriate degree of independence. That is one reason for the U.S. courts' rule that prohibits experts from accepting contingency payments. In addition, testifying experts must reveal their hourly fee.

Economists are not licensed to ply their trade, which means that forensic economists who abuse their science can go on offering tainted opinions. For academic economists, a poorly reasoned written testimony or a blunder in court testimony may become the subject of professional gossip, but other than possibly diminished reputation, other sanctions are unlikely. More formal peer review enters after a case is long over. A high proportion of published empirical work on cartels is now published from data obtained in forensic settings. Some of this

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<sup>15</sup> More experienced litigators are well aware of the professional pride uppermost in the values of their experts and are unlikely to pressure experts. Instead, counsel are likely to interview experts in advance and vet their candidates with previous clients. This process often leads to experts being pigeon-holed as either "plaintiffs' experts" or "defendants' witnesses."



work does not meet publication quality (e.g., Jeon and Shin 2005). These sanctions do not apply as forcefully to full-time professional experts.

Since 1993 a process known as the *Daubert* challenge has become common. The essence of the decision was to allow experts to be disqualified by a judge if the other side is able to show that the expert's methods are heterodox or untested. This ruling brings into forensic economics the idea of peer review and general scientific acceptance, but makes the judge the arbiter. It also means that experts should not introduce methods that are at the frontiers of their science. Some counsel now seek affidavits from experts commenting on their expert witness' qualifications. In some European countries judges can fine experts for testifying about shoddy work (Markoff 2005).

## **The U.S. Industry**

Most U.S. forensic economists work in the private sector, but hard data on the size of this industry are hard to come by.

The proliferation of cartels in the 1990s has generated large fees for law firms with expertise in antitrust law. Large civil settlements mean large legal fees for plaintiffs' law firms. The antitrust revenues of major U.S. law firms reached historic highs (*The National Journal* July 15, 2000). At one leading firm with 120 antitrust lawyers, antitrust revenues were \$64 million in 1999, up 13-fold from 1992. Five U.S. law firms employed from 100 to 150 antitrust lawyers each, most of them working in Washington, D.C. or New York City. Most of the work was generated by merger approvals; merger filings, of which there were 5000 in 1999, cost the firms from \$1 to \$5 million in legal fees. Price fixing conspiracies probably rank second in antitrust revenues. The global scope of the cartels has stimulated U.S. law firms to expand abroad. Several U.S. firms now derive more than one-quarter of their revenues from work outside the United States.

Formerly derided for drumming up business in a manner akin to that of personal-injury lawyers, antitrust plaintiffs attorneys are now increasingly accorded somewhat greater respect for their skills and methods of operation. Instead of being pejoratively referred to as "ambulance-chasers," they are now more often described as entrepreneurial firms assisting social justice.

The elevated stature of antitrust plaintiffs' counsel is illustrated by a lengthy admiring profile of attorney Michael Hausfeld in the *Wall Street Journal* (January 4, 2000). His firm, Cohen Milstein, has been involved in high profile civil lawsuits against handgun manufacturers, German companies that enslaved workers during World War II, Swiss banks that did not return the assets of victims of the Nazi holocaust, and oil companies accused of causing pollution. Hausfeld calls these actions "social reform" class-action suits because they can mitigate injuries not being addressed by legislatures or regulatory agencies. More conservative

publications refer to Hausfeld as a “corporate shakedown artist.” Hausfeld, together with well known lawyers David Boies and Kenneth Adams, led the civil treble-damages lawsuit against the vitamin cartel. In that case, plaintiffs were represented by 18 law firms, while the six defendants had hired at least 42 firms.

Plaintiffs’ law firms almost inevitably represent buyers on a contingency basis, which implies that the firms must bare the costs of prosecuting a case for up to three or four years for uncertain future rewards. Contingency fees may be negotiated by the clients, but most antitrust plaintiffs join a federal class whose legal fees will be determined by a supervising judge. The traditional system of contingency fees rewards plaintiffs’ counsel with a fixed percentage of the settlement amounts won by the plaintiffs. This system encourages attorneys to settle for the highest amount that defendants can be persuaded to pay yet also provides incentives to economize by settling prior to a drawn out court battle.

Connor (2001: Table 18.1) contains a list of civil antitrust price fixing cases for which information is available on attorney fees. In a sample of class-action suits from the 1970s and 1980s, Elzinga and Wood found that legal fees and costs<sup>1</sup> averaged \$190,000 per case. While these fees may seem rather modest, so were the average values of the settlements – only \$640,000 per case. That is, on average legal fees represented about 30 percent of the total awards made to private treble-damages recipients, or 42 percent of the net recovery to the plaintiffs. However, these data show that the larger the size of a recovery, the smaller the ratio of legal costs to recovery amount. Moreover, the largest settlements tend to have been made in more recent years. Indeed, for the top eight settlements the legal-fees percentages are only one-sixth to one-half the rates found by Elzinga and Wood (1988). Thus, it appears that there are fixed costs in representing a civil treble-damages case, or at least some threshold level under which most law firms choose not to accept this type of legal action.

Many legal writers and federal judges have expressed concerns about excessive legal fees in class action cases. The decline in the percentage of settlement awards paid out as legal fees probably represents in part a reaction against perceived over-generous awards in the past. Some judges have tinkered with various methods of calculating fees and costs in order to develop fairer decision rules. Some years ago judges seem to favor the “loadstar” method, which required plaintiffs attorneys to submit timesheets and other cost documentation. However, the loadstar method cannot address the issues of fair hourly rates or reasonable profit rates.

In the lysine case, the supervising judge implemented a novel fixed-fee auction to keep legal costs low, but the perverse incentives introduced by a fixed-fee approach were fairly widely condemned (see Chapter 16). Overall, the tide seems to be turning back toward approving percentage contingency fees or fee amounts arrived at by negotiation with the parties to the suit. However, in a treble-damages price-fixing case settled in late 2000, customers of two New York

City auction houses were represented by class counsel chosen by an auction operated by the supervising federal judge (*Wall Street Journal* December 6, 2000). Instead of bidding fixed fees, law firms submitted minimum amounts of recovery guaranteed to the plaintiffs; the amounts of the settlement *above* that minimum were used to generate legal fees at a rate of 25 percent. When this case was settled, class counsel received only 5% of the payout to the class. This type of auction preserves the incentive of class counsel to bargain for the highest possible recovery for the plaintiffs while simultaneously insuring relatively low percentages are paid to class counsel.<sup>2</sup>

There are free-rider issues in setting legal fees in class action suits generally. When a large number of geographically dispersed suits are consolidated and certified as a federal class, a “lead” firm or small number of firms is designated to represent the entire class. If the class is composed of a large number of small plaintiffs this arrangement works quite well. However, typically there is a wide range of sizes of buyers, and the interests of small and large buyers diverge. In nearly all the civil cartel cases examined in this book, many large plaintiffs opted out of the class because they wanted a larger recovery and they could afford to pay for high quality legal representation. In the most extreme case, buyers of bulk vitamins that accounted for three-fourths of purchases opted out of the federal class. As a result the opt-outs became free riders on the efforts of lead class counsel because the latter helped establish a floor on settlement rates. The plaintiffs who stayed in the class essentially ended up paying for legal services that the opt-outs benefited from.

The vitamins case illustrates a curious reversal of the usual free-rider phenomenon. In that class action, the federal judge overseeing the case approved legal fees of \$122 million for about 60 law firms that represented direct buyers of bulk vitamins (Table 18.1). Those fees were a modest percentage of the recovery to be paid out to class plaintiffs. However, most of the larger plaintiffs became convinced that the settlement was far too low (about 20 percent of affected U.S. sales) compared to treble damages computed by their economist experts (about 100 percent of sales). In March 2000, some 200 plaintiffs representing 76 percent of vitamin purchases opted out. Because of an unusual *reverse* most-favored-nation clause in the settlement, the opt-ins will have their recovery increased if the opt-outs negotiate a more generous settlement rate.<sup>3</sup> Should this happen, the small plaintiffs who stayed in the class may become free riders on the legal costs of the opt-outs. Why the judge would approve legal fees for a rump class is most puzzling; the fees are likely to climb to about 45 percent of class recovery.

In examining the available data on legal fees, it must be kept in mind that not all treble-damages filings result in settlements of any kind. In these situations, the law firms obtain no revenue for their time and expenses. In addition, many cases are settled out of court before a class is approved, and on such cases virtually no information is available on legal fees.

Finally, legal costs are incurred by the defendants. By their very nature, defendants tend to be large companies with lots of experience in defending themselves from allegations of many kinds. Most have in-house counsel for routine matters, but when defending themselves on matters involving large liability tend to hire additional outside counsel. In the cartel cases examined in this book, defendants availed themselves of the most prominent and high priced U.S. antitrust law firms. Moreover, unless they were granted amnesty, defendants had to defend themselves in a legal war that had three fronts: prosecution by government antitrust agencies in as many as ten jurisdictions, civil suits by direct buyers in several nations, and civil suits by indirect buyers in up to 16 U.S. state courts.

Consequently, defendants' legal costs were often higher than the legal fees awarded plaintiffs' counsel. ADM, for example, had to retain multiple law firms to defend itself in the government's criminal cases (lysine and citric acid), two parallel federal civil cases, state-level indirect buyers' suits, and derivative shareholders' suits; ADM's executives were provided with separate counsel, as was its board of directors. ADM's total legal expenses amounted to at least \$50 million. If other defendants in the lysine, citric acid, and vitamins cases paid proportional amounts, scores of defendant's law firms benefited to the tune of about \$180 million. Law firms representing private plaintiffs probably received 15 to 20 percent of the settlements in the same three global cartel cases, or \$350 to \$450 million. Therefore, not counting the modest costs of DOJ prosecution, these three cartel cases conservatively generated a total of \$530 to \$630 million in gross revenues for the U.S. law firms representing plaintiffs and defendants.

Doubtless many will regard such enormous sums as sad evidence of a hyper litigious society. They *are* wasteful expenditures in the sense that many were incurred simply to cancel the effects of expenditures by parties on the other side of the dispute. However, in the end most of the legal expenses are simply a necessary outgrowth of constitutionally guaranteed rights to due legal process. And as high as they were, these legal transactions costs may be low when compared to the economic costs of the alternatives: monopolistic distortions in affected markets or regulatory approach that requires regulatory commissions for price controls.

### **Forensic Economics in Europe**

It is notable that of the 18 authors that contributed to an edited volume of advanced methods in forensic economics, not one is located at a European institution (Slottje 1999). In fact, 16 were affiliated with U.S.-based institutions,

and the other two worked in Australia. I believe that this is evidence of an undeveloped forensic-economics industry in Europe.<sup>16</sup>

One of the reasons for the paucity of such work in Europe may be traced to taste or status in respect to economic research in general. In my survey of about 500 publications looking for cartel overcharges, I was struck by the small proportion written by scholars outside of North America.<sup>17</sup> Nearly all economic articles are written by North American academics using cartel episodes that affected commerce in the United States or Canada.<sup>18</sup> The absence of empirical cartel studies by European or Asian academics is striking, as is an abundance of works that contribute to advances in theories of collusion. In other words, in cartel publications the empirical/theoretical ratio is high in North America and low on Continental Europe.<sup>19</sup>

One might speculate as to why this is so. The supply of well trained industrial economists in Europe is unlikely to be an explanation.<sup>20</sup> However, the structure of academic departments at European and Asian universities may explain the paucity of useful studies. Compared to U.S. departments of economics, European departments tend to be smaller (perhaps falling below the threshold necessary for collaborative teamwork on large-scale data sets), more focused on IO theory, and have different expectations for Ph.D. dissertations. Finally, a survey of European and North American industrial-organization economists reveals that there are very few attitudinal differences between the two groups on economic theory, but the former were less likely to expect economists to influence competition policies (Aiginger *et al.* 2001).

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<sup>16</sup> The terms “forensic economics” and variants hardly ever turns up in the European press (Lexis Nexus search). One recent article asserted that consultant’s rates in Europe are roughly the same as those in the United States (Markoff 2005)

<sup>17</sup> Admittedly, limiting my survey to works in English probably exaggerated this impression, but I did attempt to locate books in German and French also. I examined books, journal articles, working papers, government reports, court and commission decisions, and other short analyses of cartel price effects. Many were written primarily as historical case studies and mention price effects only in passing; most such papers contain no references to price changes but are valuable because they are based on primary documents that give details about internal organization. The majority of the short cartel studies were written by economists; the focus in these studies is on testing hypotheses or an improved estimation method for overcharges; many are so focused on their method that they do not contain enough information to derive point estimates of the overcharge rate.

<sup>18</sup> Several historical studies of cartels were authored by European or Japanese economic historians. Contributors to two or three conferences on cartels sponsored by the League of Nations in the 1930s were from various nations of Western Europe. The greatest evidence of empirical interest in cartels is from the dozens of studies of industries issued by the UK Monopolies Commission beginning in the late 1940s. A few recent economic studies of cartels were written by UK or Australian economists (Evenett, de Roos).

<sup>19</sup> The UK is in an intermediate situation, but even in the UK *academic journal* publications are heavily weighted toward contributions to the microeconomics of collusion and away from empirical studies of cartel conduct and performance. Indeed, prior to the 1950s I was able to locate only one overcharge estimate in a British economics journal.

<sup>20</sup> The principal European organization for industrial economists (EARIE) was more active in sponsoring meetings the past decade than its U.S. counterpart (IOS), and the EARIE meetings had a good proportion of empirical and legal-economic papers.

Perhaps a more important factor explaining the weak status of European the near absence of private antitrust suits (Ashurst 2004). Because private civil cases are unusual in Europe, so the little work being done on cartel overcharges is done in-house by antitrust authorities. This inhibits the ability of academics to obtain access to the structural and price data needed to calculate overcharges using advanced statistical methods. Unlike North America, there is little mobility between the staffs of European antitrust authorities and universities or think tanks.

## METHODS

The major role played by economic analysis in horizontal price-fixing cases is the calculation of the *overcharge* on buyers in markets affected by a cartel. The overcharge is the value of purchases of a cartelized product actually made minus what the sales would have been for the same volume of product absent the cartel. The overcharge can be measured as a percentage of affected commerce (this is the familiar Lerner Index of market power) or as a percentage of sales *absent overt collusion* (this is the mark-up on the but-for price). Accurate estimates of conspiracy-induced overcharges are important not only because of recovery of civil damages, but also because overcharges are the basis for the calculation of government fines. Under the U.S. antitrust laws, a successful plaintiff is entitled to treble the dollar overcharge, which is then multiplied by the number of units purchased.<sup>21</sup>

Information on actual transaction prices and quantities sold is usually readily available from the parties in such cases, and defendants may reveal proprietary cost data as well. See Figure 1 for an example. But the unobserved “but-for” price must be inferred using economic reasoning.<sup>22</sup> The principal challenge for forensic economists is to calculate the relatively competitive benchmark price for each collusive sub period. Reasonable economists will often arrive at different benchmarks for the same set of facts.

Two features of estimating cartel damages help simplify the analytical task. First, the market-definition problem so critical in monopolization and merger cases, is usually not an issue. Cartelists self-define the appropriate product market. Second the time period for *intended* cartel price effects is usually an admitted fact. Actual market price changes often will lag by several weeks the starting date and by several months the ending date. It is possible that the cartelists achieved

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<sup>21</sup> Equivalently, one may compute the *percentage* increase in price for each time period during the conspiracy, and then multiply these percentages by the *value* purchased in each period.

<sup>22</sup> Single damages under the law in most court circuits are precisely equivalent to the income transfer due to the exercise of market power. Single damages are slightly higher than the stream of monopoly profits accruing to the cartel members, because operating the cartel requires the expenditure of some management resources. In some circuits, the dead-weight loss may be permitted as an additional source of damages (Page 1996). Some legal theorists argue that a buyer's lost profits is a conceptually superior measure of damages (Hovenkamp 1998, p. 658).

no pricing power in the market. However, in most cases the collusive period is treated as parametric information.<sup>23</sup>

There are five generally recognized methods of calculating an overcharge (Page 1996, Hovenkamp 1998). Proving an antitrust injury in U.S. courts depends on the preponderance of the evidence in the case, but the *amount* of damages is decided according to a lower standard, that of reasonableness. As I understand the term, reasonableness requires a “formula” (a precise method of calculation) that can be applied to data likely to be available to the analyst. Each of the five methods of computation below will meet the legal standard of reasonableness, and forensic economists often will examine more than one method to see if they are mutually supporting.

### **The Before-and-After Method**

This method has been used to calculate antitrust damages in U.S. civil cases since at least the 1920s (Hovenkamp 1998, p. 661), and it was one of the methods used in the treble-damages lysine case. “Before-and-after” is something of a misnomer; it should be called the “with-and-without (collusion) method.” The “before” period is really any nonconspiracy period -- whether before, after, or during an intermediate pause in price-fixing. It is important that the “before” period be one that is quite comparable to the conspiracy period with respect to demand and supply conditions. Shifts in buyer preferences, appearance or the disappearance of substitutes, or changes in the cost of production of the cartelized product during the affected period can cause overstatement or understatement of the overcharge.

A pre-cartel price is often presumed in legal settings to be the competitive price. “Cartel members . . . enjoy no presumption that they already had market power before the illegal act was committed” (Hovenkamp 1998, p. 660). However, even if a pre-cartel period was arguably one of oligopolistic tacit pricing conduct, the pre-cartel price is still a reasonable benchmark so long as the competitive determinants of pricing conduct did not change when the cartel was formed. That is, the before-and-after method is free of assumptions about the nature of the industry’s non-cartel, noncooperative conduct; it may be purely competitive or

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<sup>23</sup> In the lysine case, the length of the time period of the affected period was an issue that divided experts for the two sides (Connor 2001). It is usually uncontroversial to use the conspiracy period for the affected sales period, but in the lysine case the defendants had not yet agreed to plead guilty. Consequently, the opt-out plaintiffs had to depend on press reports to define the affected period. Plaintiffs chose August 1992-December 1995 to be the affected sales period. In fact court testimony would later reveal that the lysine cartel had two episodes divided by a brief price war in the spring of 1993. Defendants’ experts decided that only the second episode was effectively cartelized. (White 2001) refers to an “unusual and suspicious” pattern of “uncharacteristic stability” in lysine transaction prices from September or October 1993 to February or March 1995 (see Figure 1).

tacitly collusive (perhaps Cournot). Prices during the post-cartel period or during an intracartel price war might also serve as reasonable benchmarks. However, post-cartel benchmarks may be affected by learning during the conspiracy; that is, when a cartel is formed in a competitive industry, its members may learn how to price tacitly after the cartel breaks up. If true, the overcharge would be understated. If prices fall to short-run marginal cost levels during a price war, the overcharge may be overstated.

Choosing the months to employ for the before price requires judgment. If real prices were fairly constant for one to three years before a cartel began, then averages of these one, two or three years' prices might serve well as benchmarks. One problem often encountered is that cartel formation frequently occurs after a recessionary period in the industry; if so, then the benchmark price might be understated and the damages overstated. A predatory episode prior to cartel formation will strongly overestimate the overcharge, as happened in lysine. On the other hand, older pre-cartel prices could have been generated by a previous cartel episode unknown to plaintiffs. This seems to have been the case in the vitamins cartels in 1985-1989 (Figure 8-2).

Similarly, post-cartel prices can be equally problematic benchmarks. Ideally, conduct may be a reversion to noncooperative equilibrium. However, defendants may enter into a period of unsustainably low pricing to mollify their angry customers. Alternatively, the cartel experience may allow its participants to form more stable conjectures than were possible before the cartel existed, in which case even uncooperative conduct inflates post-cartel prices because a sort of carry-over effect of cartel behavior. Harrington (2004) developed a model in which former cartelists keep prices high in order to reduce their liabilities in follow-on civil suits.

Most commonly, the analyst draws a straight line from the before price forward until the end of the cartel or backward from the after price to the beginning of collusion. A slightly more sophisticated approach is to draw a straight line from the before price to the after price. If it has an upward slope costs probably increased and vice-versa. Figure 12-1 illustrates this approach from a damages analysis prepared for the U.S. vitamin E cartel suit. Plaintiffs alleged that most of the vitamins cartels had organized cartels in 1985-1989, an allegation that complicated the calculation of damages. Bernheim (2002) judged that there was a brief period of pricing in late 1999 that would serve as a relatively noncooperative benchmark; also, he decided that collusive carry-over effects on prices had dissipated after about 12 months.

Seasonality of demand is a difficult issue to deal with in a before-and-after analysis, especially when there are few non-cartel period price observations. Later, evidence came to light that seasonality of demand for lysine was well recognized by the managers of the cartel (Connor 2001: 211-212). It arises from swine feeding practices of producers in the temperate zones. Demand for animal



feed rises in the winter months, which results in an increase in the derived demand for lysine in the fall of each year. Econometric methods are better equipped to handle seasonal shifters than the simple before-and after method. Because collusion is best timed to begin when seasonal demand rises, ignoring this factor will lead to an overestimate of damages.

### **The Yardstick Method**

The *yardstick* approach involves the identification of a market similar to the one in which prices were fixed but where prices were unaffected by the conspiracy. A yardstick market should have cost structures and demand characteristics highly comparable to the cartelized market, yet lie outside the orbit of the cartel's influence. Typically, the yardstick method is most useful when applied to cases of geographically localized price fixing or bid rigging. Markets with nonstorable products, with high transportation costs relative to price, and for localized services are good candidates for the yardstick method. The yardstick method has been used in markets for bread (Mueller and Parker 1992), fluid milk (Porter and Zona 1999), and construction services. With global cartels like lysine and vitamins, the yardstick method could not be applied.

Choosing an analogous market requires judgment that is best informed by a deep study of the market and cartel practices. It is best justified by examining price movements in the affected market and the analogous market before and after the cartel period. If monthly prices for two or three years are highly correlated, then the analyst has some assurance that the analogous market was a proper choice. The overcharge is then calculated by the differences in prices between the affected market and the yardstick market.

### **The Cost-Based Approach**

During the 1998 criminal trial of three ADM executives for lysine price fixing, prosecutors introduced the confidential production and sales records of ADM's lysine department as exhibits. These internal records (now public documents) provided ADM managers with monthly plant output and several costs (labor, energy, dextrose, other chemicals, overhead expenses, transportation, storage, and sales-office expenses) during the five years 1991-1995. Figure 2 plots these costs of manufacturing and distribution against monthly physical plant output using regression analysis.

The plot appears to show considerable "scale economies" for levels of output up to 10 or 11 million pounds. In fact, the diagram really captures strong learning-by-doing effects, because all of the observations below 11 million pounds are drawn from the pre-cartel period (February 1991-June 1992). Abundant testimony and the manufacturing records themselves support the fact that nearly

all of the high-cost months were ones with “yield failures” due to contamination of fermentors.<sup>24</sup> As ADM learned how to sanitize its plant’s fermentation reactors, contamination episodes ceased and the costs of spoiled-product disposals disappeared. To a minor extent, unit costs also declined with increasing levels of output because fixed costs were being spread over larger units of production.

The most important feature of the average-total-cost curve shown in Figure 2 is the portion above 10 or 11 million pounds per month. During the conspiracy, plant output always exceeded 10 million pounds. Statistically, this portion is completely flat. It is true that manufacturing costs were affected by short run changes in the price of dextrose, which in turn was closely related to the market price of corn. Nevertheless, total manufacturing costs hewed quite closely to the average of \$0.63 per pound whenever production exceeded 10 million pounds. As plant output edged closer to the maximum 18-million-pounds level, unit fixed costs dropped a bit. However, the decline in fixed costs was nearly perfectly balanced by higher selling costs incurred as ADM shipped higher shares of its U.S. production to overseas destinations. Thus, after June 1992 (the likely cartel period), average total accounting costs of manufacturing and sales varied only within the \$0.73 to \$0.78 per pound range and were statistically unrelated to the quantity produced. Adding a fairly generous return on investment of 6% of sales brings the average total *economic* costs to \$0.77 to \$0.83 per pound of lysine.<sup>25</sup>

In competitively structured industries, profit-maximizing firms accept prices that are equal to their long run marginal costs. Because ADM’s total costs were effectively constant during the cartel period, it follows that the but-for competitive price would have been just about \$0.80 during the affected period. This observation is reinforced by the fact that ADM’s costs of production were equal to or lower than all four of its rivals in the lysine industry (Connor 2001: 217). The full-cost price of \$0.80 seems like a decent but-for price.

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<sup>24</sup> In every case when costs jumped above about \$0.80 per pound, the lysine/dextrose yield ratio dropped below 30%. Such episodes became rare after June 1992 or when production was above 10 or 11 million pounds.

<sup>25</sup> This is generous because it is ADM’s own rate of return during fiscal 1990-1995 when its profits were bloated by several commodity cartels (Connor 2000, app. A). It is also well above the average return earned by publicly traded companies in similar industries.

## The Constant-Margin Approach

The constant-margin approach is a variation on the before-and-after and cost-based methods. Instead of analyzing prices, variable costs become the focus of the analysis. It assumes that the cartel members earned profit margins from noncooperative conduct prior to and after the cartel; the “but-for” benchmark is an implicit gross margin that remains constant for the affected period.

The forensic economist must study production methods intensely. Costs of production are collected for the pre-cartel, cartel, and post-cartel periods. It is desirable to use input prices drawn from competitive markets. Relying on costs from the internal records of participating firms is perilous, especially for durable cartels because of X-inefficiencies that may develop during collusion.

An example of this approach is illustrated for the vitamin E conspiracy in Figure 12-5. The results are not too different from the straight-line before-and-after method (Figure 8-2). Indeed, the damages estimates from the two methods are quite close.

## Using Game-Theory to Check Results

The defendants in the lysine cartel provided a second rebuttal to the plaintiffs’ before-and-after analysis. They asserted that a noncooperative form of collusion was more probable than perfect competition had the cartel not operated (Warren-Boulton 1996). Further, the defendants specified the homogenous Cournot model as the most appropriate one, because of its long-standing acceptance and widespread analytical use in economics. Over certain ranges of market conditions, that model predicted equilibrium prices that fell within the range of actual market prices observed during the cartel period. That is, the Cournot model implied that the cartel had been ineffective raising prices by *explicit* collusion above prices generated by *implicit* (and legal) pricing coordination. Thus, the overcharge was zero.

Predictions from specific oligopoly models require structural parameters. In particular, the Cournot formula for calculating the profit-maximizing price needs three pieces of market information: the Herfindahl index of concentration, the own-price elasticity of demand, and the marginal cost of production. About the first item there was no disagreement; the Herfindahl index for three domestic manufacturers and two importers during the conspiracy was about 3,500.<sup>26</sup> The

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<sup>26</sup> Implicitly this assumes that a global cartel was viewing the U.S. market as geographically distinct from others. Internal records of the cartel’s pricing decisions and its efforts to prevent geographic arbitrage tend to support this view. Global concentration was about 2,500 in 1994 (Connor 2001a, tbl. 8.A.3).

other parameters were borrowed from the plaintiffs' own opinion, namely that document's assertion that \$0.70 was the marginal cost (or close to it) and that the elasticity was around  $-0.5$  to  $-1.0$  during the cartel period.<sup>27</sup>

One problem with the Cournot model is that the formula can, under some ranges of parameters, predict impossible prices. In layman's terms, the model can "blow up." For example, if the demand for lysine is highly inelastic (less than  $-0.35$ ), then Cournot oligopolists would be predicted to set negative prices, no matter what the cost of production. Negative prices are rarely observed in natural markets, because prices generally must be set above the variable costs of production, and these costs are always nonnegative. Another problem with Cournot is that it is only one of many plausible oligopoly models; its popularity with economists rests more with its mathematical tractability than its consistency with the organization of natural markets. Given the lysine parameters just discussed, other equally plausible models such as price leadership by ADM produce equally untenable market price predictions. Moreover, the model that many economists would agree is the second most popular, the homogeneous Bertrand model, predicts *competitive* prices when there are two or more sellers. Finally, although possibly allowable as evidence in antitrust cases, the degree of econometric literacy required to comprehend formal oligopoly models greatly restricts their use in forensic settings.

## Econometric Modeling

With sufficient time and access to detailed price and cost information, statistical modeling is often the preferred analytical approach of forensic economists in estimating antitrust damages (see, e.g., Slottje 1999). When all the necessary data have been received from defendants during discovery and cross-checked for accuracy and completeness, the econometric analysis itself could take as little as six months or as long as a year. Two or three years time is not unusual.

With a rigorous model that is shown to fit the market's actual performance over time, the legal goal of isolating the effects of a defendants' illegal conduct from all other market forces would appear to be achievable. Econometrics seems ideally suited to identifying ". . . the only casual factor accounting for the difference between plaintiff's actual experience in the damage period and its but-for period. . ." (Page 1996: 36). Law journals and handbooks for lawyers in the antitrust field frequently include material on regression analysis for damages calculations (e.g., Fisher 1980, Page 1996, and Hovenkamp 1999). Baker and Rubinfeld (1999) and Brander and Ross (2005) provide nice surveys of the method.

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<sup>27</sup> Connor (1996) opined that feeds were manufactured under fixed proportions, which implied poultry, swine, or meat elasticities of  $-0.10$  to  $-0.50$ . These are retail-level elasticities calculated from precartel, more competitive periods; at the higher cartel-period prices, the elasticity will be higher in absolute value. This discussion took place in the context of his analysis of the dead-weight loss from cartel pricing.

Econometric estimation employs reduced-form equations using multiple regression methods.<sup>28</sup> The structural model assumes that both the quantity demanded and the quantity supplied are dependent simultaneously on the market price. One of two econometric approaches regresses market price on observations from collusive and noncollusive periods. The right-hand side of the equation contains variables representing variable input costs (wages, materials, energy, inventories, and possibly exchange rates<sup>29</sup>) and variable that will capture sources of demand (customer incomes, buyer output levels, seasonal dummies, and prices of substitutes). The key variable is a dummy variable taking a value of one for each period during which the cartel is assumed to have effectively raised prices. If the model has a good fit, even if the coefficient of the time dummy is not highly statistically significant, the coefficient is the unit mark-up overcharge. Such models are in essence elaborations of the before-and-after method, but they are better able to handle exogenous shifts in demand and supply.

If the analyst believes that price fixing may have influenced costs of production, then the dummy variable for time will underestimate the price effect of collusion. In this case the appropriate approach is to fit a reduced-form regression to only the pre-cartel period. The regression coefficients on all the independent variables are then used to *forecast* the but-for price during the cartel period. In this approach, all the demand and supply variables can vary during the cartel period. Figure 12-1 shows the results of such analysis for the vitamin E cartel. Alternatively, if insufficient numbers of observations are available in the pre-cartel era, one can fit a model to post-cartel data and *backcast*. Froeb *et al* 1993) illustrate this method for a U.S. bid-rigging scheme in frozen fish.

Econometric modeling has become the world standard for proving cartel damages. Yet, econometric estimation has some disadvantages compared to the other four methods mentioned. It is data-hungry; dozens of demand or cost variable may have to be collected, and less than 40 or 50 non-cartel observation periods may produce statistically fragile estimates. The mathematical form of the equation is not specified by theory, and the specification of independent variables may become issues too abstruse for the fact-finders to comprehend. Biased estimates may result if post-cartel pricing conduct does not return to pre-cartel conduct. From a rhetorical stance, it is advisable to apply statistical methods but supplement with other approaches and hope that they are mutually consistent.

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<sup>28</sup> NEIO methods could be used to measure price effects from a simultaneous equation system built upon Cournot or Bertrand pricing assumptions. The greatest advantage is the fact that data only from the cartel period would suffice. The main disadvantages are that it is more time-consuming, relies on accounting costs supplied by the defendants, is more difficult to explain to lay audiences, and is quite demanding with respect to data on market structure. Such models are unusual in forensic settings.

<sup>29</sup> Bernheim (2002) makes the interesting point that overcharge estimation in the U.S. bulk vitamins market need not adjust for exchange rates even though imports account for the majority of supply. He asserts that the raw materials used to produce vitamins, many of them petroleum derivatives, are denominated in U.S. dollars.

## **Dynamic Simulation Modeling**

De Roos (2006) is an example of how well simulation can fit the facts of a cartel, in this case the global vitamin C conspiracy. This method holds promise for calculation damages, but because it is so novel in applications to cartel studies, it would probably not pass a Daubert challenge in U.S. courts.

## **CONCLUSIONS**

One of the hallmarks of a rigorous scientific discipline is the ability to measure parameters of interest with precision. From this perspective, the highly variable estimates often presented of cartel overcharges could be interpreted as reflecting badly on empirical economics. For example, the lysine-cartel overcharge estimates varied by as much as ten-to-one when the first civil suit was being resolved. A more sanguine view that of progressive analyses often show a movement toward greater precision, a movement made possible by additional information and the time to apply more complex analytical methods. At the very least testimony by opposing experts may yield a range of damage estimates within which parties will settle or a fact-finder will choose a compromise.

Modern cartel enforcement is a paradox. The stated goal of antitrust laws of most nations is deterrence, and optimal deterrence requires that cartel penalties be based on multiples of economic injuries. Yet antitrust authorities are typically reluctant to calculate fines on the basis of damages because of perceived analytical challenges (ICN 2005). In my experience rough but reasonable estimates can be quickly prepared using one of several methods delineated in this paper, especially when investigations collect appropriate economic data. More often than not, alternative estimates of cartel overcharges tend to be mutually supportive. Econometric modeling is more time- and skill-intensive but does not necessarily yield a superior estimate (Connor and Bolotova 2006). The reluctance of antitrust authorities to base fines on seems to be based on an abundance of caution.

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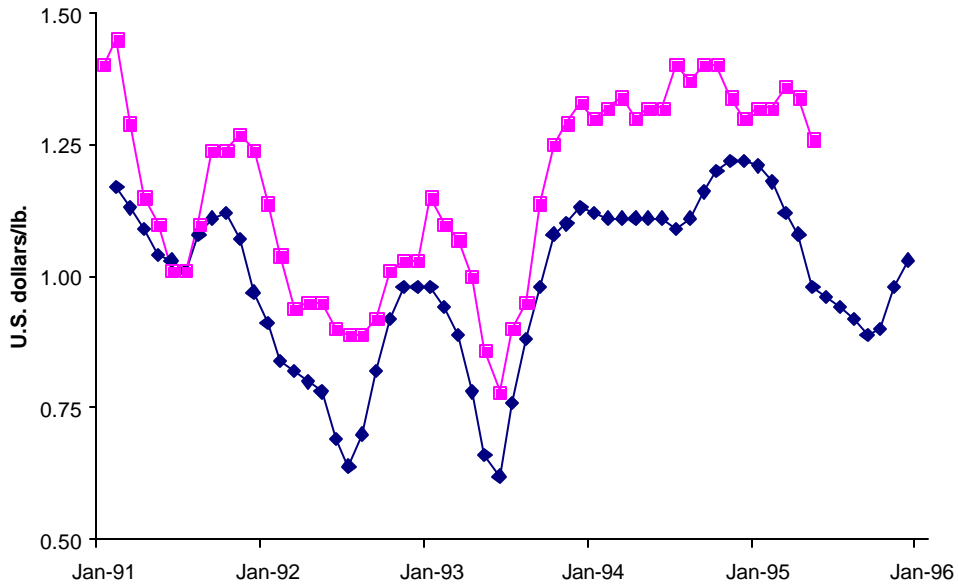
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Warren-Boulton

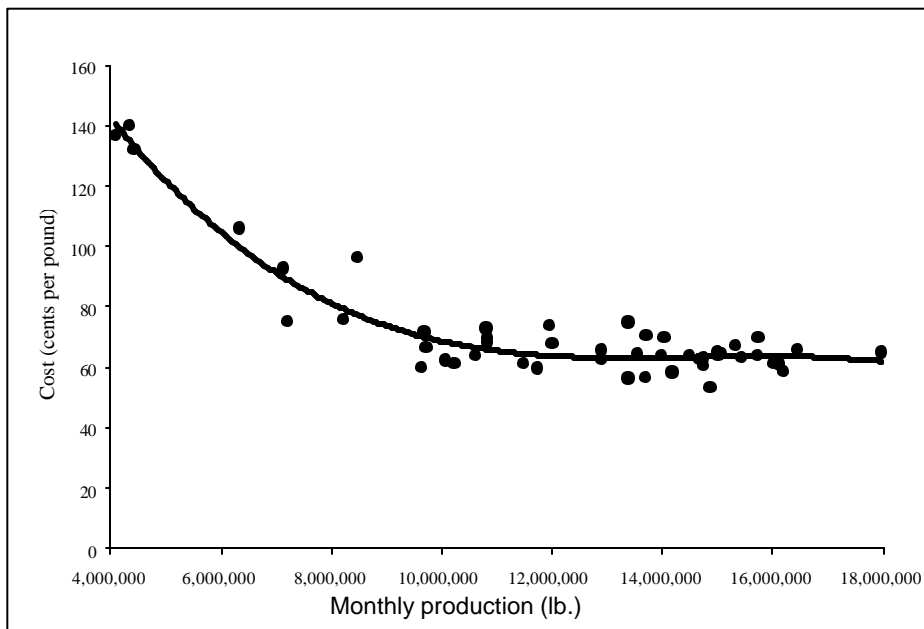
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**Figure 1. Lysine Transaction Prices, U.S. and EU Markets, 1991-1996.**

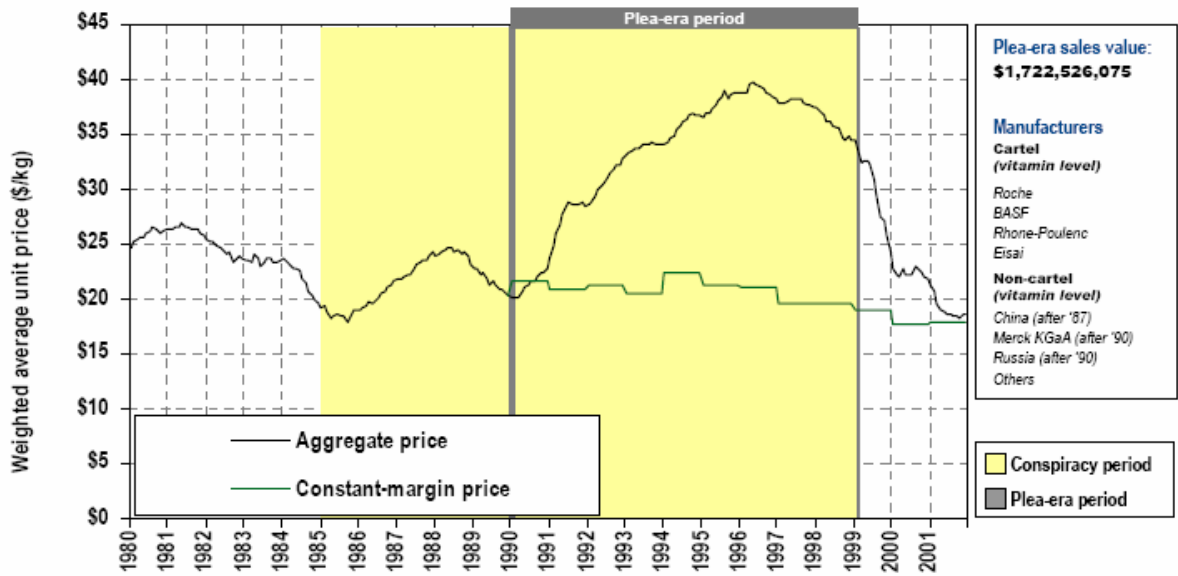


**Figure 2. ADM's Lysine Manufacturing Costs, 1991-1995.**



Source: *U. S. v Michael D. Andreas et al. (1998) Tr. Ex. 60-67.*

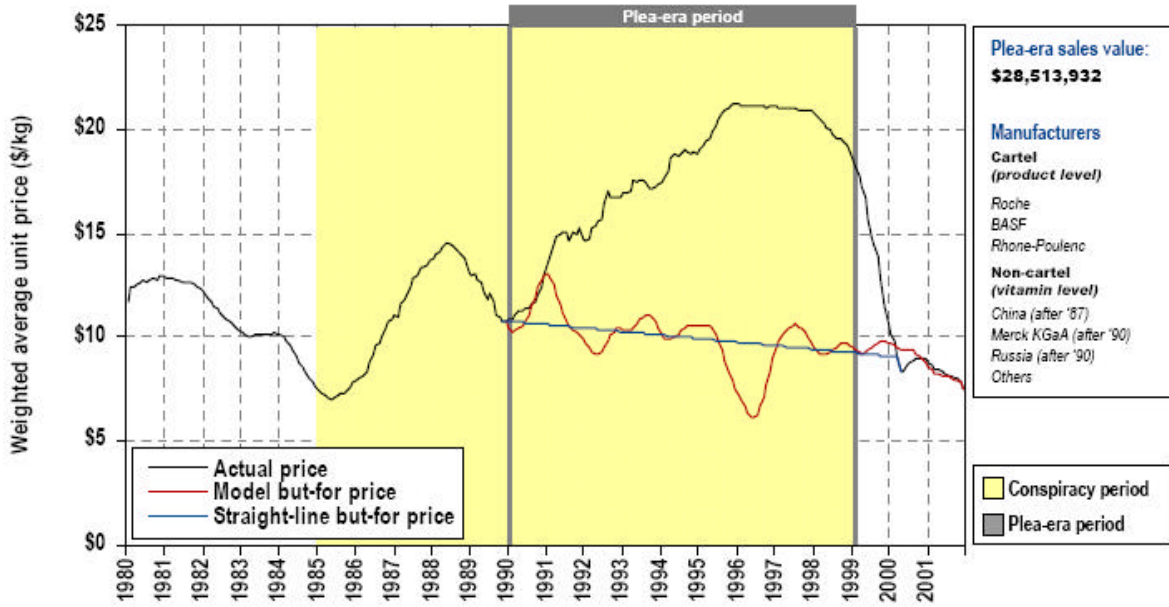
Figure 12-5: Vitamin E aggregate 100 percent basis price with constant-margin price



Source: 7-month centered moving average for U.S. "tel quel" feed, food, pharma, and cosmetic price from Roche ROVIS data and contribution margin data from Roche Data Books

Source: Bernheim (2002).

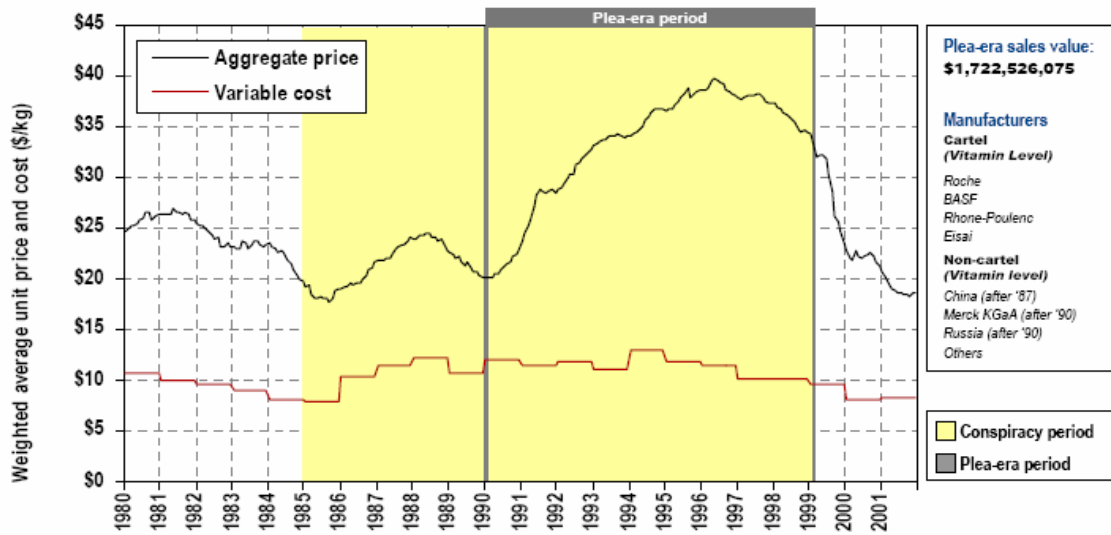
Figure 12-1: Vitamin E Acetate 50% Spray-Dried Feed Grade price and but-for price



Source: 7-month centered moving average for U.S. "tel quel" feed price from Roche ROVIS data

Source: Bernheim (2002).

Figure 9-1: Vitamin E aggregate price at 100 percent basis and variable cost



Source: 7-month centered moving average for U.S. "tel quel" price from Roche ROVIS data and contribution margin data from Roche Data Books

Source: Bernheim (2002).