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THE GREAT GLOBAL VITAMINS CONSPIRACIES, 1985-1999 *

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ABSTRACT

This paper is a comprehensive examination of the global bulk vitamins cartels of the 1990s. In terms of its precision and breadth of coverage, the quantitative information now available on vitamins surpasses that of almost any other modern cartel. For example, the internal records of the major defendants have yielded monthly transaction prices for 53 bulk vitamin products over periods of up to 22 years.

Evidence is presented that these 16 interrelated cartels were the largest discovered international price-fixing schemes of the late 20th century in terms of affected commerce and direct overcharges. On the other hand, the percentage increases in bulk vitamin prices wrought by the cartels were merely average. The formation of the cartels by and large occurred in markets that were in terms of their structures and historical modes of behavior ideally suited for overt collusion. Although organizationally similar in many respects, the cartels also displayed a wondrous variety of collusive conducts. Only four to six of the cartels died natural deaths.

There is little question that the convicted members of the vitamins cartels were in absolute monetary terms the most heavily sanctioned defendants in the history of antitrust law. Yet, it is equally non-controvertible that the impressive corporate monetary sanctions imposed worldwide were inadequate to deter recidivism.

Keywords: Cartel, collusion, price fixing, antitrust, optimal deterrence, chemicals

JEL Classification Nos. L41, L44, L65, L11, L13, N60, K21, K14

INTRODUCTION [1]

Basel, Switzerland is an historic city of about a half million people located at the intersection of the French, German, and Swiss borders. Home to Switzerland's first university established in 1460, the city played a pivotal part in the Protestant Reformation. Although the city houses many architecturally important medieval buildings, manuscript and art collections, and a pretty late-Gothic Rathaus fronting the central market place. Basel does not receive nearly as many tourists as it does business visitors. Aided by its fortuitous location on the Rhine River, Basel was the Swiss city most affected by the 19th century forces of industrialization. By the turn of the century, it had become the center of Switzerland's chemical and pharmaceutical industry, second only to Germany's in Europe. Basel pharmacist Felix Hoffmann-La Roche was the founder of a pharmaceutical manufacturing partnership that would become a global leader in medicinal products. Its corporate successor, Roche Holdings, remains headquartered in the city of its birth and is still controlled by the founding families.

Switzerland has a long history of hosting meetings and secretariats for international cartels. In recent decades that tradition intensified, because Switzerland remained outside the jurisdiction of the European Union (EU), making surprise inspections by European Commission competition-law authorities impossible. Basel in particular became an important locus for most of the vitamins cartels. By virtue of Hoffmann-La Roche's headquarters and its proximity to the headquarters of the other leading vitamins conspirators, Basel may well be able to lay claim to the title of World Capital of Global Cartels.[2]

To paraphrase an Iranian propaganda slogan, the vitamins cartel was the "Mother of All Global Cartels." It was the first, biggest, most elaborate, longest lasting, and most harmful of the international cartels discovered by the U.S. Department of Justice (DOJ) the 1990s. Moreover, the success in vitamins spawned the formation of other international cartels. The initial steps in establishing global conspiracies in vitamins were taken in 1985, but these early efforts required renegotiation and the addition of more products and more conspirators in 1988 and 1989. Most of the vitamins cartels did not end until early 1999.

By 1990 the early signs of financial success in vitamins price fixing were so convincing to the participants that they were moved to explore the feasibility of forming more feed or food ingredient cartels. Memoranda have come to light that show the citric acid cartel was formed in 1991 by Hoffman-La Roche explicitly because of its profitable prior experience in vitamins.[3] Then the cartel contagion spread within Archer Daniels Midland (ADM) from its citric acid division to its lysine operations in 1992.[4]

[1] Dates and other facts about the vitamins cartels can be found in Appendixes D and E of Connor (2000) and Connor (2001).

[2] The global citric acid cartel also had its first meeting in Basel (Connor 2001: 135). Switzerland was until 2002 the operational headquarters of the global cartel for gem diamonds, De Beers Centenary AG.

[3] ADM was involved in at least two U.S. price-fixing conspiracies prior to 1991, carbon dioxide and high fructose corn syrup. In 1991-92 ADM became the prime mover in two more cartels, the global citric acid and lysine cartels (Connor 2001).

[4] Ironically, after a cartel is discovered by antitrust authorities, much like the methods used by public health officials to trace the spread of venereal diseases, a reverse contagion process works to assist in cartel prosecutions. Under the corporate leniency programs of the United States, the EU, and other jurisdictions, amnesty for antitrust violations can be obtained if a company under investigation agrees to cooperate with officials by revealing a cartel in a second product market.

From 1988 to 1992 21 chemical manufacturers headquartered in seven nations joined the bulk vitamins cartels, and the number of markets infected by price fixing would grow 16 distinct products.[5] Sales by these cartels exceeded $30 billion, an amount that is quite likely the largest of any discovered international conspiracy since 1990 (Connor 2003). The pharmaceutical manufacturers involved became virtually addicted to the infusion of monopoly profits, giddy financial results that prompted the conspirators to continue their clandestine activities for up to 15 years. These illegal activities persisted in the face of several public prosecutions of parallel conspiracies, multiple antitrust investigations of the vitamins industries, mounting economic sanctions by antitrust authorities, and strenuous efforts to stop the collusion by some of the conspirators' own company lawyers. The conspirators simply burrowed deeper and developed more elaborate methods of subterfuge.

The vitamins conspirators erected a mechanism of customer exploitation that incorporated almost every technique of cartel organization that had ever been devised. These exploitive techniques resulted in historic monopoly overcharges on customers. Buyers of animal feeds; of fortified foods; of meat, poultry, fish, eggs, and milk; of vitamin supplements; and of cosmetics in every corner of the world paid inflated prices for these goods. These overcharges later appeared as extraordinarily high profits on the income statements of the participating vitamin manufacturers.

Most of the conspiracies were exposed to the world one day in May 1999 at a widely publicized Department of Justice press conference in Washington DC. Eventually, the antitrust authorities of at least nine countries and the European Union would open formal investigations of the vitamins cartels, and several of them would impose record fines on the companies involved.[6] For the first time in the history of the 1890 Sherman Act, the United States imprisoned several high-ranking foreign executives for price fixing. In addition to actions of government prosecutors, more than 100 law suits were filed by buyers of bulk vitamins in the United States, Canada, Australia, and the United Kingdom seeking compensatory and punitive damages. In 2004 the U.S. Supreme court became involved in the vitamins cartels by issuing a ruling that significantly altered the way in which defendants in international cartels can be sanctioned. By the end of 2005, the members of these cartels had in absolute dollar terms become the most harshly punished antitrust violators in the history of the world.

Despite the heavy sanctions imposed by prosecutions around the world, the most somber lesson to be drawn from these dreary episodes is that the crime of price fixing pays.

[5] Every commercial vitamin except K and D2 were cartelized. One of the 16 products is "other carotenoids," which consists of four compounds each with unique uses.

[6] The United States, Canada, EU, and Australia each imposed record monetary fines. Two early investigations of the French competition-law council failed to discover incriminating evidence. As of early 2005, Brazil's antitrust authorities were still investigating, Mexico's decision was unknown, Japan's and Switzerland's had decided to issue only cease-and-desist orders, and New Zealand's had exceeded the statute of limitations.

INDUSTRY ORIGINS [7]

The discovery and commercialization of vitamins typically evolved through five stages (Kiple and Ornelas 2000). First, physicians would describe and name a disease of unknown etiology. Second, a dietary cure would be identified empirically, but the active ingredient responsible for the cure is not understood. In some cases folk remedies provided clues. Third, scientific researchers isolate a compound that is known to be curative. Sometime an unused letter of the alphabet was provisionally assigned to the vitamin at this time. Fourth, usually within a few years the chemical structure of the vitamin would be identified. The vitamin's chemical name would sometimes require its letter to be redesignated or a number added. Fifth, chemists would find a method of synthesizing the vitamin. At this point, patents could be issued and commercial production would begin on a small scale. Engineering improvements would subsequently permit cost reductions, and the falling price would stimulate mass-market demand. Sometimes demand would spurt well before dietary deficiencies were identified for the vitamin or all a vitamin's curative powers understood.

Companies with experience in making organic chemicals and marketing human health products were the best positioned to be pioneers in vitamins. In the late 19th and early 20th centuries, sellers of vitamins started by extracting them from plant or animal materials relatively rich in the vitamins of interest. However, the greatest period of growth for the vitamins industry occurred in the 1930s and 1940s when the techniques of synthetic chemistry began to be applied to large-scale industrial production. Long in use for dyestuffs and certain pharmaceuticals, synthetic chemistry permitted manufacturers to substitute less expensive raw materials, to achieve economies of scale in production, and to make final products of greater purity than could be achieved with extraction methods.

Uses of Vitamins

The value of certain foods in maintaining health was enshrined in customary culinary practices that predate written history (Tannahill 1988). Moreover, pre-modern medical texts make it clear that physicians with no notions of vitamins prescribed effective dietary cures for diseases now known to be caused by vitamin deficiencies. For example, night blindness was diagnosed by Egyptian physicians, and in texts dating from 1520 BC beef liver was prescribed as a cure (Kiple and Ornelas 2000). Classical Greek medical manuscripts repeat the diagnosis and cure. Hundreds of years before nutritional experiments confirmed the wisdom of the practice, fish-liver oils had been administered as a folk remedy in Northern Europe for certain deficiency diseases. By the 1840s, cod-liver oil had become a common dietary supplement in North America and Western Europe, demand being met by supplies out of fisheries in Newfoundland and Norway.[8] Published European controlled medical experiments from 1861 onwards verified the efficacy of cod-liver oil in overcoming a deficiency in ocular retinol, long before scientists were to realize that fish and animal livers are rich in vitamin A. Finally, in 1929-1934 scientists proved that beta carotene is the precursor of retinol in the eyes of animals and that vitamin A is essential to vision.

[7] Most of the facts cited about the history and manufacture of vitamins can be found in Achilladelis (1999), Hui (1992), Kiple and Ornelas (2000), Trager (1995), Bernheim (2002a), Connor (2001:277-304), and Connor (2000: Appendix Tables D and E).

[8] Oral applications of bitter cod liver oil were still maternal best practice in the United States until the 1960s, as the present author can testify.

Inspired by informal observations of ships' officers, scientists in the late 18th century demonstrated that the addition of citrus fruits to the diet would prevent the onset of scurvy. As a result, in 1795 the British Navy decreed a daily ration of lemon or lime juice for all seamen on long voyages. That citrus juices were high in vitamin C would become apparent to scientists in the 1920s.

In the late 19th century, the cause of a rising incidence of beriberi in the Indonesian population was discovered by Dutch scientists. The introduction of polished white rice had removed some then unknown substance in the germ and coating of brown rice that prevented beriberi in rice-based starchy diets. Another important step in scientific understanding was research published in 1906 by British biochemist Frederick Hopkins. He showed that many foods had substances that could not be classified as carbohydrates, proteins, fats, or minerals. Then, in 1912, chemist Casimir Funk identified the anti-beriberi substance to be an amine (a compound containing nitrogen). Thus, he proposed that it be named "vitamine" a neologism that combined the Latin word *vita* ("life") with "amine."[9]

In 1912, Hopkins and Funk proposed the vitamin-deficiency theory of nutrition. This theory postulates that minimal amounts of vitamins must be ingested in order to avoid the appearance of certain diseases or functional impairments. Among the diseases they believed were caused by vitamin deficiency were scurvy, beriberi, pellagra, and rickets. Over the next three decades or so, this theory would be verified for more than 20 vitamins, popularly known by their letters or letter-number combinations (e.g., B12).[10] Research showed that minute quantities of 13 or 14 vitamins are necessary for the regulation of metabolic functions in humans, animals, and even some bacteria and yeast.[11] Vitamins can also cure anemia and dermatitis, assist blood coagulation and reproduction, and are related to cancer and heart disease. The need for specific vitamins varies across species. A compound that is an essential vitamin for one species is not necessarily required by another species. Levels of vitamins required also vary by gender and growth phase. For example, in humans one type of vitamin D is synthesized in the skin tissue when it is exposed to sunlight. The enzyme produced by vitamin D regulates the conversion of calcium into bone. However, children deprived of adequate sunlight may require dietary supplements of vitamin D during phases of rapid skeletal growth to avoid arrested or deformed bone development. Residents of the Nordic countries are advised to consume relatively large amounts of vitamin D. Pregnant and lactating mothers often require different and larger amounts of vitamin supplements than other women.

Today, almost half of the sales of bulk vitamins are "animal grade."[12] Indeed, some vitamins are purchased primarily or exclusively for inclusion in animal feeds. The principal components of animal feeds are pasture grasses, hay or silage crops, or the so-called rough grains (maize, millet, sorghum, and the like). Surplus food grains or byproducts of food

[9] Later, when scientists determined that many other vitamins do not contain nitrogen, the final "e" was dropped.

[10] The urgency of research into the causes of malnutrition was spurred by the discovery that fully two-fifths of all young men called for military conscription in the UK in 1917-1918 were medically unfit because of diseases traced to vitamin deficiencies.

[11] Technically, most vitamins act as enzymes, coenzymes, or precursors of coenzymes; many vitamins undergo chemical changes after being ingested in order to arrive at their functional (coenzyme) stage and may further chemically change before reaching an active (enzyme) stage. The enzymes then become catalysts in regulating various metabolic processes. Unlike minerals and the macronutrients (proteins, carbohydrates, and fats), vitamins are not converted into energy or building materials for tissues.

[12] Bulk vitamins sold for animal feed or pet food may contain somewhat higher proportions of impurities than those destined for human consumption. As a result, feed-grade bulk vitamins typically sell at a discount from human-grade versions. For most vitamins the discounts are in the 5% to 15% range, but for vitamins A and E the price differences are closer to 50%. New entrants into a vitamin industry will usually begin making feed-grade products before offering pharmaceutical-quality products.

processing are also incorporated into animal feeds. Under more intensive modern farming practices, animals are fed supplements high in proteins, minerals, amino acids, and vitamins. These relatively costly ingredients are called concentrates; approximately 0.5% by weight of a typical feed concentrate consists of bulk vitamin "premixes."[13] Mature cattle, sheep, and other ruminants are able to synthesize vitamins in the first of their stomachs (the rumen) from grains or roughage. However, like humans, animals with single stomachs will benefit from supplementary vitamins to enhance the rate or type of growth or to increase production of eggs. Swine, poultry, fish, and immature ruminants are fed the most of vitamins produced today. A small but fast-growing source of demand is the biotechnology industry, which needs vitamins to optimize the metabolism of micro-organisms during fermentation. The great majority of the sales of vitamins A, E, B2, B3, B4, B5, B12, D, K, biotin, canthaxanthin, and folic acid are purchased for animal and fish feed (Table 1).[14] Some carotinoids function as colorants for the flesh of poultry or fish.

[13] Vitamin premixes are primarily sold to feed manufacturers. Only about 4% of the value of premixes consists of filler, the rest being bulk vitamins. Premix formulas vary systematically by animal species and the age, stage of life, and gender of the animal. One seller in the vitamins cartel sold thousands of premixes.

[14] In the mid 1970s the feed/food/pharma breakdown in Europe was approximately 60/15/25 (EC 1976:2). Thus, the relatively size of the channels have changed only slightly in the past 20 years.

Table 1. Relative Size of the Feed, Food, and Pharmaceutical Channels for Vitamins

	World 1987-1998			U.S. 1990-1998		
Product	Feed	Food	Pharma	Feed	Food	Pharma
				Percent [a]		
E	73	3	23	34	13	52
C	8	50	42	1	66	33
A	87	6	7	85	7	8
B4 Choline chloride	100	0	0	100	0	0
B5 Cal Pan[b]	69	3	22	40	9	51
B2 Riboflavin	75	8	17	18	31	51
B3 Niacin	73	11	14	43	25	32
B6	42	8	49	1	14	85
H Biotin	85	4	10	75	7	18
B12	58	2	40	30	3	67
B1	35	16	49	1	24	75
D3	93	3	4	43	0	57
Folic acid (B9)	79	17	15	16	44	40
Beta carotene	8	64	28	10	47	44
Other carotenoids [c]	92	7	1	23	77	1
Total	43	26	30	40	24	36

Source: März (1996) and Bernheim (2002a: 32-60).
-- = Not available
[a] Percent of value of sales. Feed includes pet food and vitamins used in blends and premixes. Some rows may not add to 100% because of cosmetic and technical uses or because of rounding.
[b] Calcium pantothenate.
c) Includes primarily canthaxanthin but also astaxanthin, apocarotenal, and apo-ester.

Besides as supplements in animal feeds, bulk vitamins are purchased for human use in pharmaceutical and food products. In the mid 1930s when synthetic vitamins were first marketed to the public as pharmaceuticals, they were regarded as the "wonder drugs" of the age because of exaggerated claims that they would cure several human diseases.[15] Initially, their high prices and prescription-only status confined them to the wealthy, but by the end of the decade huge cost reductions made vitamin supplements affordable to most consumers in high income countries. Research continues today on the role of vitamins as antioxidants that may help avoid heart conditions, colds, or cancers.

Nowadays, about 30% of world production ends up in pills and capsules for purchase over the counter as nutrition supplements. Except for vitamin B4, large amount of all the vitamins and carotinoids are purchased by pharmaceutical companies to be mixed and packaged for sale directly to consumers (Table 1). Indeed, the primary use of vitamins B1, B6, and B12 is for human nutrition supplements. In more recent years, it is common to find vitamin E and other vitamins added to cosmetics and skin creams.

Also in the 1930s, scientists began to advocate the fortification of foods as a public health measure. Fortification of butter, margarine, and other dairy products with Vitamin D was initiated in 1933 and became common in the late 1930s. By the early 1940s fortification became mandatory or customary in flour and bakery products of high income countries. Mandatory fortification was accelerated to some extent by food rationing necessitated by World War II. Today the food processing industries of most countries purchase large quantities of vitamins A (and its precursor beta carotene), B1, B2, B3, B6, folic acid, and C to fortify a wide range of foods and beverages. Food fortification accounts for about one quarter of total global demand for bulk vitamins.

U.S. demand for various forms of bulk vitamins is in general similar to global demand.[16] Pharmaceutical uses are somewhat higher in the United States than the rest of the world, and this is true for every individual vitamin as well except vitamin C. On the other hand, vitamin C and the other carotinoids are used more heavily in the U.S. market for food and beverage fortification. U.S. feed applications of vitamins also vary considerably from global uses.

Vitamin Manufacturing Methods

Drug production is a branch of the chemical manufacturing industry group. Pharmaceutical raw materials may be plants, animal byproducts, or other biologic products; inorganic elements and compounds; or organic compounds. Allowable raw materials and purity standards are usually specified by a national formulary or pharmacopoeia.[17] The oldest drugs, now called crude drugs, were obtained from biologics that were cured, ground, and dried or preserved in solutions by apothecaries. Modern industrial methods of production can also involve extraction from natural sources, but preparation from biotechnologies or chemical synthesis is now more typical.[18] Both of these modern methods awaited advances in organic chemistry that began in the late 19th

[15] One of the first companies to offer multi-vitamins was Vitamins Plus, a New York firm established in 1937.
[16] The global data are more accurate than the U.S. data.
[17] In the United States, the acronym "USP" is used to signify products that meet the standards required by the *U.S. Pharmacopoeia*.
[18] The potency of vitamin D can be increased by exposing milk or other foods containing provitamins to ultraviolet light. Patents on this process were awarded to the University of Wisconsin in the 1920s.

century. The first drug made by synthetic chemical means was Antipyrine in 1884 (Achilladelis 1999).

In the case of extraction methods, a material containing the drug is placed in water or a solvent, and then the active ingredient is separated by distillation, skimming, pressing, filtering, or centrifuging. For example, cod livers can be suspended in warm water until their oil rises to the surface. The oil that is skimmed off is rich in vitamins A and E.

Synthesis is a less expensive process than extraction and generally produces a purer product. Synthetic organic compounds are produced from chemical reactions that rearrange the molecular structures of two or more chemical elements or compounds, at least one of which must contain carbon. The reactions are caused by heat, pressure, acids, or other catalysts. Many different types of reactions are used to synthesize vitamins. Sometimes the same vitamins will be synthesized by different pathways depending on a manufacturer's raw materials, equipment, or access to proprietary technologies. The expertise required to master synthetic processes comprised of multiple stages of reactions may take decades for a manufacturer to acquire (März 1996). Plants using synthetic methods are complex and large in scale; lowest costs are achieved only when running at nearly full capacity (UKCC 2001). That is, there are formidable technological barriers to entry in many bulk vitamins industries.

Biotechnologies are quite different. They harness the metabolism of microbes in biological systems using generally inexpensive carbohydrates (dextrose, sucrose, starches, etc.) as the source of carbon. Except for the final separation and purification, the fermentation process is a single-stage operation during which cascades of chemical reactions occur within the microorganism. In principle, the simplicity of these biotechnologies allows them to be commercialized at more modest scales of production than those required for synthetic methods of production. A two-stage fermentation technology was developed in China around 1990 that resulted in significantly lower costs of production for vitamin C than the synthetic process used by European and Japanese manufacturers (UKCC 2001: Table 2.1). By the mid 1990s, almost 30 Chinese companies were using this process; aided by high world prices in the early 1990s, the Chinese industry's low costs allowed it to capture more than 20% of the world market for vitamin C by 1995. Even when prices later declined, the Chinese share held close to one-third of the global market.

Advantages in production efficiencies will accrue to biotechnology manufacturers that select the most productive microorganisms and improve their productivity through genetic manipulation. Genetically improved microorganisms can be patented. Almost 100 biotechnologies for the production of vitamins were patented from 1985 to 1995 (März 1996:31). By the mid 1990s, a significant portion of the markets for vitamins E, B2, B5, H (biotin), and D3 were being made solely via biosynthesis.[19] The Archer Daniels Midland Company has made a strong commitment to producing vitamins from fermentation of corn sweeteners. It already makes and markets vitamins E and B2 and produces biotin for captive use by means of various fermentation technologies. However, harnessing biotechnology for vitamin production still faces many technical hurdles. For example, ADM's 1996 annual report featured its new world-class vitamin C plant, yet five years later production had not yet been launched (UKCC 2001:10).[20]

Sometimes synthetic and biotech manufacturing methods are combined. For vitamin C the traditional Reichstein method combines fermentation with chemical processes. This was the technology employed by the three leading manufacturers, Roche, BASF, and Takeda Chemical Industries, in the 1990s. This method required a fermented intermediate material called

[19] When sold for human use, vitamins made by biosynthesis may be labeled "natural" and command higher retail prices than their otherwise identical synthetic versions.

[20] The *Chemical Market Reporter* (February 23, 1998) speculated that the collapse of vitamin prices after 1995 – the year the vitamin C cartel disbanded – might have made sales unprofitable.

ketogulonic acid (KGA). Three European chemical companies (BASF, E. Merck, and Cerestar) owned a joint venture that was one of the few sources of KGA.

For certain end products biotechnological processes are not always the cheapest. Vitamin B2 can be made by either a single-step fermentation process or by a process that combines fermentation with synthesis. The first method results in a product that is 80% pure, the standard grade for animal feeds. The second combined method is more expensive but produces a final product that is 96% pure. To prepare vitamin B2 that is acceptable for food and pharma uses (98% purity), the cost of purification makes the fermentation approach more costly than the synthetic method.

Besides the introduction of fermentation methods in a few of the vitamins industries, other process innovations were being made (Bernheim 2002a: 34-60). In the late 1980s and early 1990s, a new "variable catalyst" production method was adopted in the choline chloride industry. In the mid 1990s, Roche and BASF developed novel technologies for making beta carotene and canthaxanthin. It is noteworthy that in none of these three markets did the new technologies interfere with effective collusion. In 1999, the year the cartels ended, Daiichi and Lonza began manufacturing vitamins B5 and B3, respectively, with superior processes. Therefore, a minority of the vitamins industries experienced a degree of technological innovation. However, for the great majority of vitamins (A, E, B1, B3, B5, B6, B9, B12, and D3), there were virtually no major changes in production technology from 1980 to 1999.

Chemical synthesis often produces vitamins of greater purity than when they are made by strictly fermentation processes. Pharmaceutical-grade vitamins often must reach 98% purity to meet national quality standards, whereas feed-grade vitamins are acceptable at lower levels of purity. In the case of vitamin B2, chemical synthesis produces a fine powder of 96% purity (UKCC 2001:9). With modest additional costs a pharmaceutically pure product can be marketed. Vitamin B2 produced by fermentation is less costly and yields an 80% pure product that has a consistency more amenable to the preparation of premixes; although technically feasible, the costs of converting the fermented version of B2 into human grade would raise its price above the synthesized product. Therefore, synthesized B2 tended to be made into human-grade product while fermented B2 was sold to animal-feed buyers.

Early Development of the Industries

Most of the early development of the vitamins industry occurred first in Germany, Switzerland, and the United States (Achilladelis 1999). In each case, these countries offered strong patent protection for new products and processes. Moreover, manufacturers were assisted by strong ties to leading researchers in organic chemistry in universities. Like all scientific innovations, commercial development of new pharmaceuticals evolves through at least four stages: the isolation of the chemical and identification of its molecular structure, production of the compound via chemical synthesis, pilot production, and large-scale manufacture usually accompanied by cost reductions and mass-market acceptance. Preceding and accompanying these innovations were clinical studies that identified vitamin-health relationships.

Despite the worldwide depression of the early 1930s, this was the decade of the most dramatic growth for the chemical industry in general and the pharmaceutical branch in particular (Henahan 1976). The rapid pace of scientific discoveries in vitamins and pharmaceuticals that began just before World War I fed a speedy adoption into commercial production by chemical companies in Europe and the United States. Vitamins became an important segment of the pharmaceutical industry's boom period. Roche, Merck, Pfizer, and many other drug makers opened or expanded their research laboratories and developed close relationships with university chemistry departments.

The basic research in isolating and identifying the chemical structures of the 13 essential vitamins[21] began with vitamins D and E in 1922, B1 in 1926, C in 1928, and all others between 1931 and 1948 (Appendix Table 15). Roughly half of these discoveries took place in U.S. laboratories and the rest in Switzerland, Germany and the UK. Methods for synthesizing vitamins came quickly in the 1930s and early 1940s.[22] Commercial production often began at least on a pilot scale within a year of patenting or publication of a feasible method of synthesis.[23] By the end of the 1930s, synthetic chemistry had made possible large-scale, low cost production of vitamins E, C, B1, B2, B3, and B4.

Some other vitamins and provitamins took longer to reach commercial production. Vitamin E was discovered around 1922. However, it was not until 1936 that the chemical structure of the first of its four forms, alpha-tocopherol, was identified. Two years later, scientists working with Hoffmann-La Roche first synthesized vitamin E. Demand grew slowly at first because the physiological functions of vitamin E were not understood until the 1970s. For a few vitamins the delay was more than ten years. Vitamins A and crystalline D3 were commercialized between 1949 and 1959, one or two decades after their synthetic chemistry was known, perhaps because natural fish-liver oils were so plentiful. Another product that was late to be developed is the provitamin[24] beta carotene. Part of a class of provitamins called carotinoids, beta carotene was first synthesized in Switzerland in 1953. Although manufactured from 1954, regulatory approval as a colorant was delayed until 1964. It is now sold in large quantities as a natural orange colorant for some foods and as a feed ingredient for farm-raised seafood. Growth of beta carotene has been aided in part because, unlike vitamin A, it is not toxic in large doses. Three more recent carotinoids provide red, pink, and gold hues.[25]

Roche Takes Leadership

Hoffmann-La Roche was the first company to learn how to synthesize most of the vitamins and provitamins. Its first commercial success was synthetic vitamin C (ascorbic acid), which it introduced to the market in 1934.[26] Roche's entry into mass production of vitamins C, B1, B5, and B6 was the result of purchasing the rights to technologies developed in the United States, but afterwards Roche was the global leader in scientific discoveries of vitamin chemistry and production technologies (EC 1976: 4). By 1938 Roche had mastered the synthesis and bulk manufacture of vitamins A, B1, B2, B5, B6, C, D, E, K1, and biotin (H) through synthetic chemistry (*ibid.,* Achilladelis 1999). Indeed, in 1938 vitamins and multivitamin preparations were Roche's major source of sales.[27]

[21] There is scientific controversy as to whether choline chloride is essential. Niacin was discovered in Germany in 1867, but its nutritional value was not recognized until 1936.
[22] Synthesis was announced in scientific journals for vitamins D (1930), B3 and B4 (sometime in the 1930s), C (US 1932 and Switzerland 1934), B2 (Germany and Switzerland 1935), B1 (UK 1937), B1 (US 1937), A (Switzerland 1937), B5 (US 1938), E (Switzerland 1938), B6 (US 1939), K (Netherlands 1943), biotin (US 1945), and B12 (US 1948). The first of the four carotinoids to be synthesized was beta carotene (Switzerland 1953).
[23] For 11 cases where the two dates are known, the median delay was two years and the mean delay five years.
[24] Provitamins are chemicals that change into vitamins after ingestion and metabolism. Beta carotene is a provitamin of vitamin A.
[25] They are canthaxanthin, astaxanthin, and citranaxathin, respectively. Only the first of these three had significant sales by the late 1990s.
[26] Roche marketed 50 kilos of vitamin C directly to end users that year (www.roche.com/home/company/com_history_1920.htm).
[27] *Ibid.*

Roche maintained a monopoly position in vitamins A, E, biotin, B5, and beta carotene for an average of 20 years (Appendix Table 15). Its monopoly in the large market for vitamin E was not broken for 28 years, when the Japanese chemical company Eisai entered in 1967. After 1950 Roche extended its product line to folic acid and carotinoids and began selling vitamins for animal feeds by the late 1960s. In the 1970s, Roche cemented its early lead in vitamins for animal feeds by offering optimization programs and extensive after-sales service to feed manufacturers (EC 1976: 4). Although significant entry into vitamin manufacturing had begun, in the 1970s Roche remained the world's dominant supplier of synthetic vitamins, with a global market share of 50 to 60 percent. Roche was the dominant supplier of vitamins A, B1, B5, B6, folic acid, C, D3, E, biotin, and carotinoids (Appendix Tables 5 and 6).

Some of the earliest entrants came from Europe. The big German chemical firm Badische Anilin-und Soda-Fabrik (now called BASF) was successful in imitating Roche in several vitamin-product lines. BASF first built production facilities for animal-grade synthetic vitamin A in 1970, animal-grade vitamin A in 1972, and beta carotene in 1972. It began biochemically produced vitamin B2 1990 from a purchased technology. By the early 1970s, Roche and BASF controlled more than 75 percent of global vitamin production, with especially strong positions in vitamins A and E. The large French chemical maker Rhône-Poulenc began producing vitamins A, E, D3, and B12 sometime before the 1980s, but tended to specialize in feed-grade products. Another big German chemical company, Hoechst, entered B12 manufacturing, Solvay dominated vitamin D3 production, Lonza was the premier source of B3, and the small chemical maker E. Merck was producing vitamins C, B2, B6, and B12. In the early 1980s these seven companies controlled 80% or more of global production in nine vitamins: A, E, B2, B3, biotin, B12, D3, and the carotinoids.

Vitamins in the United States

In the 1920s U.S. scientific prowess in organic chemistry was slightly behind that of German and Swiss research institutions (Achilladelis 1999). However, it caught up rapidly in the 1930s, partly because of the amalgamation of virtually all German chemical companies into the I.G. Farben monopoly in 1925. The absence of rivals on the domestic market dulled Germany's technological edge. Swiss and American companies also benefited from the expulsion of Jewish scientists from Germany. Merck and Co.[28] became the most R&D-intensive U.S. pharmaceutical company in the 1930s. In 1933 its first research director decided to focus on vitamins, and by 1937 Merck had implemented new production processes for making vitamins B1, B2, B3, and C. Vitamins B5 and B6 followed in 1940. By the end of the 1930s, vitamins constituted a large share of Merck's total sales. However, Merck decided not to exploit its technological lead in these six vitamins in Europe and most other non-U.S. markets. Instead, it sold the European sales rights to Roche, which Roche transformed into dominant global positions two decades later.[29] Pfizer began to manufacture vitamin C in 1937 and A in 1940 using licensed technology, but by 1940 it had developed its own proprietary methods for manufacturing vitamins B2 and C. American Home Products acquired two vitamins makers in 1941 and 1943. Despite the early involvement of American companies in the vitamins industries, by the 1980s none were any longer major suppliers.[30]

[28] U.S.-based Merck was part of the German chemical firm E. Merck before World War I. It's former parent would become a member of three vitamins cartels.

[29] Merck & Co.'s patents would have expired in 1953-1957, but Roche by that time had developed the manufacturing and marketing expertise to become dominant in the global markets for vitamins C, B1, B2, B5, and B6. In 1980, Roche had an average of 55% of these markets.

[30] Choline chloride and niacin are exceptions. Roche may have acquired some of the U.S. vitamin facilities in the 1950s and 1960s.

U.S. production of the water-soluble vitamins (C and the B complex) took off earlier than the oil-soluble vitamins (A and E), perhaps because the chemistry needed for large-scale manufacturing was easier to solve. Vitamin C was first isolated and its chemical structure identified in 1932. One year later, Merck and Co. was manufacturing synthetic vitamin C from a process that used sorbitol as the primary starting material. Roche's production in Switzerland began a year later, and Pfizer soon followed around 1937 with a different synthetic chemical process. When vitamin C was first sold commercially in 1933, its wholesale price was $7,515 per kilogram. Competition and process improvements brought its price down to $97 per kilogram five years later. By the late 1970s, further technological progress had dropped the wholesale price of bulk vitamin C to $10 per kilogram.

Vitamin B1 followed a similar course. A scientist at Bell Laboratories patented a method for making vitamin B1 from bran in 1934. Merck and Co. scientists developed an improved synthetic method two years later; when vitamin B1 was sold that year by Merck, its price was $300,000 per kilogram. Five years later, the flour industry was able to begin fortification of flour because the price of B1 had fallen to $1,750 per kilogram. During World II, the U.S. War Food Administration mandated enrichment of breads and pastries with vitamin B. By the late 1970s, vitamin B1 could be procured in bulk for merely $30 per kilogram.

Manufacturing Spreads to Asia

Organized research on vitamins began in Japan in the late 1930s and picked up again in the late 1940s. Takeda Chemical Industries was an early leader In Japan in vitamin research and manufacture.[31] It would follow a strategy of specializing in the water-soluble vitamins (C and B complex) for human consumption. In 1939 a predecessor of Takeda sold locally made vitamin C, and by 1950 Takeda became the first company to sell multivitamins in Japan.[32] Production of several vitamins in Japan began on a significant scale in the 1950s and 1960s, in some cases because the original patents had expired. Synthetic vitamin B1 was commercialized in 1952. By 1955 Takeda began to export vitamin C to the United States. Takeda developed significant global market shares in the early 1980s: 18% of vitamin C, 35% of B1, 9% of B6, and 23% of folic acid (Appendix Table 6). Moreover, it entered the vitamin B2 industry in 1990. In the 1990s, Takeda had become the world's second largest manufacturer of vitamins B1, C, and folic acid; it was third in the vitamins B2 and B6 industries.

The second largest Japanese manufacturer of vitamins was Eisai Co. It began sales of pharmaceutical grade vitamin E in 1951; by 1989 it would account for 15% of the huge world market for this vitamin. The third largest was Daiichi, which became the second largest supplier of vitamins B5 and B6 in the world. Other important vitamin makers were Mitsui (B4), Alps Pharma (B5), Tanabe (B2), Sumitomo (biotin and folic acid), Nippon Chemical (B12), and Kongo (folic acid).

Japanese exports to North America and Europe increased steadily up through the late 1980s. At the same time, U.S. pharmaceutical companies largely left the field; their facilities either were closed or sold off to the leading European vitamin makers. Beginning in the late 1980s, Chinese chemical firms began to imitate the earlier success of their Japanese rivals. By the 1990s, a large number of small manufacturers in China had made the country the fourth significant location for world vitamin manufacturing, threatening to surpass Japanese production in several lines. China's growth in vitamin C output was particularly striking, aided in part by low cost production based on biotechnologies (UKCC 2001, de Roos 2004).

[31] Research on chemical synthesis of vitamin B1 began in Takeda laboratories before World War II and on folic acid around 1945 (www.takeda.co.jp/english/history/index1.html).
[32] This business was sold to Daiichi Fine Chemical Co. in April 2004 (www.m-pharma.co.jp/cgi-bin).

MARKET STRUCTURE

Because of its early technological lead and continuing improvements in the synthetic chemistry of vitamins manufacturing, Hoffmann-La Roche quickly became the dominant producer in the 1930s. While its shares of most vitamins markets slid somewhat, Roche retained its premier position throughout the 1990s, with an average 50% global share of its product lines. Roche was also the most diversified of the producers, making 13 of the 16 cartelized products and selling all of them.[33] Only BASF came close to Roche in its degree of diversification (Table 2). When the vitamins cartels were formed in 1989-1991, Roche's average global share of the markets for 14 major vitamins was 46%. BASF, Rhône-Poulenc, and Takeda Chemical Industries were second, third, and fourth, with market shares of 18%, 8%, and 7%, respectively. Thus, the four largest companies supplied almost 80% of the global market for vitamins sold in bulk or in blends. Companies below the top four tended to be specialized in the manufacturing of one or two products.

Market Seller Concentration

It is inappropriate to view all vitamins as a single market at the manufacturers' level. True, when consumers buy multivitamins at retail or when feed manufacturers purchase vitamin premixes, these items contain blends of many vitamins. However, when the multivitamin supplement makers or feed premix companies buy vitamins, it is done on a vitamin-by-vitamin basis so that they can tailor the blends to the needs of the specific target group of end users. Whether speaking of human or animal populations, the metabolic functions for each vitamin are unique. One vitamin cannot be substituted for another with the expectation of avoiding some specific health or growth problem in a given species. Moreover, the manufacturing techniques used to make one vitamin will not work to make another. The combination of factories, machines, raw materials, technical knowledge, and other supply factors are unique to each vitamin.

Thus, differences in demand and supply characteristics assure that each of the 16 vitamins falls into its own separate market. Moreover, there is a sharp distinction between bulk vitamins destined for consumption by humans and those made for animal-feed market. Human-grade vitamins must meet higher standards of purity, must be packaged in containers affording greater protection from contamination, and typically are sold in lower strengths so as to avoid toxic effects.[34] In some cases, food-grade, pharmaceutical-grade, and cosmetic vitamins may form separate markets. For example, vitamin powders would be preferred for tablets or dry food applications, whereas liquids would be needed for capsules, beverages, or skin creams. Of course, in a pinch human-grade vitamins might be substituted for feed-grade, but the typically higher prices of the former (on an active-ingredient or 100%-basis) would generally rule this out as a regular practice. Finally, within the human grades of vitamins, a distinction may be made

[33] Technically there are four carotinoids, but beta carotene and other carotinoids will be counted as two products. Vitamin premixes is not shown in Table 2.

[34] In some countries, pharmaceutical grades of bulk vitamins are purer than grades suitable for fortification of foods, but this is not typically the case. Very few vitamins have only one commercial type of vitamin.

between natural and synthetic versions, a distinction that is important for marketing purposes. Many consumers, especially those who shop in health-food outlets, will be willing to pay more for the natural version. In vitamin E, natural versions may be made with old-fashioned extraction methods or with newer fermentation techniques. In the United States, three manufacturers are specialized in the production of natural vitamin E (ADM, Eisai, and Henkel). Although only about 20 percent of total vitamin E demand, the natural segment has been growing considerably faster than the synthetic version.

The significance of these market features is that the number of suppliers will be fewer for one vitamin type than all types of vitamins in the aggregate.[12] That is, seller concentration will be higher for natural human-grade vitamin E than for all grades and types of vitamin E. Thus, in general market shares for all types of a vitamin will understate the shares held by companies in the market for one type of that vitamin.

Table 2 shows the best available data on the global production shares of the 21 corporate members of the vitamins cartels. Looking at the individual vitamins markets, it is clear that the typical product market was dominated by at most three or four firms. An alternative measure of market shares is one based on value of sales. In general production shares and sales shares are quite close (Bernheim 2002a: 30-31). The main difference is that the sales shares of the big three manufacturers --- Roche, BASF, and Rhône-Poulenc – are one or two percentage points

Table 2. Global Production Shares, 20 Companies and 15 Straight Vitamins, Early 1990s

Company	A	B1	B2	B3	B4	B5	B6	B9[a]	B12	C	D3	E	H[b]	Caro-tinoids	World Markets[c]
								Percent							
Roche	48	44	54	S	S	36	49	39	S	46	43	46	45	83	46
BASF	30	2	30	S	15	21	3	S	S	7	13	28	S	16	17
Rhone-Poulenc	21		S	S		S			62	S		13	S		8
Takeda		31	3				12	23		26					7
Eisai												12			2
Daiichi						29	12								1
E. Merck	S	S	S				5			10			10		2
Hoechst									7	S					1
Solvay	S		S							S	44	S	S		0.6
Lonza				58									5		2.3
Akzo					15										0.8
Degussa				22[e]											0.6
Reilly				22[e]											0.3
Nepera				6											0.3
Chinook					19										1.0
Mitsui					10										0.5
DuCoa					18										1.0
UCB					13										0.7
Kongo								15							0.1
Sumitomo[f]								20					17		0.6
Tanabe		S											20		0.6
Cartel total	99	77	87	86	90	86	81	97	69	89	100	99	97	100	93

S = Sold but did not manufacture
Sources = Appendix Table 6.
a) Better known as folic acid
b) Better known as biotin
c) The total bulk vitamin sales of the company divided by global sales around 1990-1991. Excludes sales of premixes. The weighted average share with global market sales as weights of Roche, BASF, Rhone-Poulenc, Takeda, Daiichi and Lonza were 50%, 20%, 19%, 24%, 21%, and 33%, respectively.
e) Degussa and Reilly were joint venture partners.
f) Sumitomo's subsidiary Sumika sold folic acid.

Table 3. Global Market Concentration in 16 Vitamins Industries, Circa 1990

Product	Firms	Four-Firm Concentration Ratio	Herfindahl Index of Concentration
	Number [a]		*Percent* [b]
E	5	99	3214
C	7	87	3013
A	4	100	3646
B4 Choline chloride	6	100	3785
B5 Cal Pan[c]	5	95	2703
B2 Riboflavin	5	94	3887
B3 Niacin	4	98	3887
B6	7	87	2927
H Biotin	6	100	2846
B12	3	97	4239
B1	4	98	3312
D3	3	100	3954
Folic acid (B9)	6	97	2683
Beta carotene	2	100	7048
Other carotenoids	2	100	7450
Vitamin premixes	3	100	4934 [d]
Mean	4.6	96.8	3980

Source: März (1996), Bernheim (2002a: iii and 32-60), and Appendix Table 6.
-- = Not available
a) There were about 50 in China; however, for the calculations in this table they are treated as one company, which overstates concentration in some industries.
[b] Percent of value of sales. Feed includes pet food and used in blends and premixes. Some rows may not add to 100% because of cosmetic and technical uses or because of rounding.
[c] Calcium pantothenate.
d) Only Roche, BASF, and Rhone-Poulenc made premixes; assumed that their shares of the premix market were the same as their shares of all straight vitamins in 1987-1999.

lower than their production shares. That implies that at the time the cartels were being launched in 1989-1990, the top three companies had lower rates of capacity utilization, whereas the remaining producers were operating at higher levels of capacity utilization. As the initiators and leaders of the vitamins cartels, the ability of the big three to quickly ramp up production with

their existing plants was a distinct bargaining advantage during the negotiations that lead to firm cartel agreements.

Table 3 summarizes the degree of global seller concentration in the vitamins industries around 1990. These data include every major producer in the world, not just the members of the cartels. One measure of seller concentration is the four-firm concentration ratio (CR4), which is the sum of the market shares of the top four sellers in a market. Mean four-firm concentration in 1990 was an extremely high 97%. Because the vitamins cartels contained all of the top three of or four producers, cartel control is almost the same as CR4 in most markets. In only three bulk vitamin markets was CR4 below 90%, namely, biotin (88%), B6 (about 75%), and B4 (67%).[35] The global markets for vitamins A, B2, B3, B9, B12, D3, E, and carotinoids are especially highly concentrated. Table 3 also shows the Herfindahl-Hirschman Index of global concentration.[36] A value of 1800 of above is considered to be dangerously high for effective market performance. The minimum index for vitamin manufacturing is 2703 and the mean is 3980. A Herfindahl index of 3980 describes an industry that is practically a duopoly, because it is equivalent to an industry comprised of two large firms with 43% of the market each and one small firm with 14%.

The number of companies needed to reach 60% or 70% of global supply control was usually two or three (Table 4). Even 90% control required only three or four companies (except five for vitamin B6). Market concentration is similar at the regional levels in Western Europe and North America (Tables 5 and 6).

Table 4. Numbers of Companies Accounting for Various Shares of Global Production

Product Market	1985 Market Share at least				1990 Market share at least			
	60%	70%	80%	90%	60%	70%	80%	90%
	Number							
Vitamin E	2	2	3	4	2	2	3	4
Vitamin A	2	2	2	3	2	2	3	4
Vitamin C	2	2	3	4	2	2	3	5
Vitamin B4 (US)	--	--	--	--	2	2	3	3
Beta carotene	1	1	1	2	1	1	1	2
Vitamin B5	2	3	3	4	1	2	3	4
Vitamin B3	1	2	2	4	2	2	3	4
Vitamin B2	1	1	2	2	2	2	2	3
Biotin (vitamin H)	1	1	1	2	2	2	3	4
Vitamin B12	2	2	3	4	2	2	3	4
Vitamin B6	2	3	4	5	3	3	4	5
Canthaxanthin	1	1	1	1	1	1	1	2
Vitamin D3	2	2	2	2	2	2	2	3
Folic Acid (B9)	3	3	4	4	2	3	3	4
Median	2	2	3	4	2	2	3	4

[35] As will be related below, the vitamin B4 manufacturers would devise a special form of conduct to solve the problem of relatively low sales concentration.

[36] The Herfindahl index takes the market shares of each seller in an industry, squares it, and sums the squared shares. A monopoly has an index value of 10,000.

Source: Appendix Table 6. -- = Not available

Table 5. EU Market Shares, 14 Bulk Vitamins, Conspiracy Periods

Company	A	B1	B2	B3	B4	B5	B6	B9[a]	B12	C	D3	E	H[b]	Carot.[c]	Total [d]
								Percent							
Roche	45	52	46			44	51	35		51	28	40	37	80	45.1
BASF	31	16	29		32	30				11	20	27	6	20	21.9
Rhone-Poulenc	24								85		10	15			7.8
Takeda		28	13				11	20		8					3.4
Eisai												11			2.6
Daiichi						12	8								0.6
E. Merck										8			5		1.9
Hoechst									10						0.0
Solvay											38				0.9
Lonza				70									8		1.8
Akzo					31										1.4
Degussa				22											0.5
Reilly				8											0.1
Nepera				0											0.0
Chinook															0.0
Mitsui															0.0
DuCoa															0.0
UCB					27										1.2
Kongo								9							0.0
Sumitomo								20					12		0.2
Tanabe													26		0.4
Cartels	100	89	88	100	90[e]	100	70	84	95[e]	78	96	92	94	100	90

Source: Appendix Tables 5 and 12.
a) Better known as folic acid
b) Better known as biotin
c) Carotinoids beta carotene, canthaxanthin, and astaxanthin.
d) Share in the European Economic Area.

Table 6. US Market Shares, 14 Bulk Vitamins, Conspiracy Periods

Company	A	B1	B2	B3	B4	B5	B6	B9[a]	B12	C	D3	E	H[b]	Carot.[c]	World Markets[d]
								Percent							
Roche	54	25	43			32	24	12	-	46	40	47	40	97	48.7
Takeda		30	17				18	28		31					11.1
BASF	13		23		0	11				2	18	22	0	3	9.8
Rhone-Poulenc	28								75		0	16			7.6
Eisai												12			3.0
Daiichi						53	13								2.0
E. Merck										6			6		1.8
Chinook					46										1.4
Lonza				34									19		1.0
Mitsui					31										0.9
Solvay											30				0.8
Nepera				28											0.7
Degussa				22											0.5
DuCoa					15										0.4
Reilly				11											0.3
Sumitomo													21		0.2
Tanabe													14		0.2
Sumitomo								21					21		0.3
Kongo								19							0.1
Hoechst									10						0.0
Akzo					0										0.0
UCB					0										0.0
Cartel	95	55	83	95	92	96	57	80	85	85	88	97	100	100	91

Source: Appendix Table 5.
a) Better known as folic acid
b) Better known as biotin
c) Carotinoids beta carotene, canthaxanthin, and astaxanthin.
d) Weighted average share in the United States.

Cartel Control of Markets

The four industry leaders attracted a total of 19 companies to the fictional collusive organization they would call "Vitamins, Inc." The four largest companies controlled 78% of world wide production of bulk vitamins. The remaining 15 smaller manufacturers later convicted for price fixing collectively controlled only about 15% of the world market, but most of these smaller companies had significant market shares in one or two of the vitamin industries.[37] Indeed, it appears that Vitamins, Inc. was comprised of *every* manufacturer of vitamins with more than a 10% share in each of the 16 cartelized markets.[38] Some of the more specialized companies have large shares in the few product markets in which they participate. Lonza, for example, was dominant in the vitamin B3 market. Only about 7% of global production remained outside the grasp of the vitamins cartels in the early 1990s, most of it in China.

In every case Vitamins, Inc. began colluding with very high degrees of worldwide control in each of the markets – 93% on average. In all but three of the markets the cartel controlled 90% or more of the market. Such high degrees of control meant that because the building of new capacity took years, the cartel was protected from entry by noncooperative price-cutters that would undermine the cartel's price increases. Moreover, market control by Vitamins, Inc. in Western Europe and the United States was practically the same as at the global level (Tables 4, 5 and 6). On average, the cartels would start out colluding with control over 90% to 91% of these two jurisdictions.

The market shares of individual manufacturers varied across the two regions in predictable ways. Most of the European firms (BASF, Lonza, Akzo, etc.) had greater penetration of the European market than the U.S. market. Similarly, U.S, firms tended to have higher shares in their home country than in Europe. Except for biotin, the Japanese manufacturers had more success penetrating the U.S. market than the European one; moreover, one can infer that Japanese and Chinese firms had higher shares in Asian markets than in Europe.

However, there are four markets in which the cartels began with lower levels of regional control than world control. In the cases of vitamins B1, B6, and B12, the cartels had much higher market control in Western Europe than in the United States; for vitamin C the reverse is true. Low regional cartel control may have contributed to the fragility of three of these cartels.

In most of the cartels control slipped during the conspiracy periods. For the nine cartels for which the information exists, five experienced significant entry by sellers outside the collusive group. Vitamins, Inc. lost about 20 percentage points of global market share from the founding of the biotin (B9) and vitamin C cartels until their demise.[39] In vitamins B1, B2, and B6 markets, the cartels lost 8 to 10 percentage points during the conspiracies. All of these are water-soluble vitamins. In four of the five cases, it was Chinese vitamins manufacturers who were responsible for the erosion of cartel control. On the other hand, despite high prices Vitamins, Inc. held on to its market shares in vitamins A, D3, H, and carotinoids. There is no information on the remaining five vitamins.

[37] The mean market share held by the smaller manufacturers was 16.6% (Table 2). In 90% of the cases, the small companies' shares were 9% or higher.
[38] The Japanese firm Alps Pharmaceutical had a 10% global share of the vitamin B5 market, and Nippon Chemical had a similar share of vitamin B12 (Appendix table 6). These are quite exceptional cases, because the next highest share of a fringe firm was 5% (Korean manufacturer E. Sung in biotin).
[39] De Roos (2004) has a sophisticated model that explains the dynamics of the vitamin C cartel.

Buyer Concentration

Buyer concentration in the bulk vitamin and vitamin premix markets is generally quite low. Animal feed manufacturers are numerous because many serve local markets; there were more than 2000 in the United States alone in the 1990s (Schiek and Connor 1997). Many large agricultural producers of pork, chicken and eggs purchase bulk vitamins directly from chemical manufacturers. There are a similar number of food processing companies[40] that purchase vitamins to fortify their products. In large markets there are dozens of pharmaceutical companies that buy bulk vitamins to make multivitamin pills or capsules. Finally, there are scores of chemical brokers and wholesalers that purchase large quantities of vitamins and resell them in smaller amounts to small farmers, feed mills, or food processors.

A report by the European Commission has some information on buyer concentration in Western Europe (EC 1976:4-5). This report noted that the dominant firm Hoffmann-LaRoche maintained accounts for about 5000 buyers for its products. Twenty-six of its most important customers accounted for merely 16% of its sales of bulk vitamins.

Homogeneity

At first blush, the markets for bulk vitamins appear to be rather heterogeneous. Within nearly all the 16 vitamin "families" (A, E, C, B1, etc.), there are those suitable for human consumption and those made for incorporation in animal feeds, and the latter cannot legally be substituted for sale to pharmaceutical or food-processing companies. Moreover, some vitamins are available in alternative physical forms, such as, oils, dry powders or aqueous solutions. Finally, all the vitamin families are marketed in a range of strengths that are based on the percentage of active vitamin compound. For example, choline chloride (vitamin B4) is typically sold in four forms: aqueous 70%-pure, aqueous 75%, dry 60%, and dry 50%. The wet forms of choline chloride tend to be preferred by different customers than the dry powders. These four items are animal feed ingredients and account for 99% of the value of all choline chloride (Bernheim 2002a: 41). Most other bulk vitamins are sold in six to 12 versions that account for the vast majority of sales in the vitamin family.[41]

Although there are multiple quality grades and strength levels available for most bulk vitamins, it is clear that for a given grade of bulk vitamin there is little or no differentiation across producers. A vitamin has a unique molecular structure with unique biological properties. Vitamins are widely viewed as "commodities," that is, products so homogeneous that delivered price net of discounts is the only factor driving buyers' decisions. For each vitamin there is likely to be one variety, typically the modal one, that drives the prices of all other varieties of the same vitamin. Human-grade tends to sell in fixed price relationship to the same vitamin's feed grade; the same is true of different strengths when converted to a 100%-pure basis. Prices of 100%-pure human and 100%-pure feed versions of the same vitamin are very highly correlated over time.[42] This customary pricing practice is convenient for collusion, because sellers need only

[40] Biotechnology companies like ADM purchase large quantities of vitamins to optimize the metabolism of the microbes they have harnessed to produce amino acids and even vitamins themselves. It is ironic that ADM received such large settlements from the vitamins cartels that it was required to report the amounts because they had a material effect on profits in some of its financial quarters.

[41] Vitamin premixes are sold in thousands of different formulas. Roche alone offered about 4,200 premixes in the 1990s (Bernheim 2002a: 187). BASF marketed almost 3,000.

[42] Bernheim (2002a: 84-121) has carefully constructed such time series for 1980-2001. Feed and human price patterns are nearly identical for all vitamins except perhaps vitamins B3 and beta carotene.

agree on one price for each vitamin, from which the prices of all other types will be priced using historical premiums or discounts.

The only departure from perfect product homogeneity may be in after-sales services provided by the leading manufacturers. In the earlier decades of the vitamins industries, manufacturers sold most of their output directly to food, feed, and pharmaceutical manufacturers. The manufacturers' representatives were in a position to pass on fresh research findings about dosages and effectiveness to their customers. Slowly, as the research moved into the public domain and government agencies set recommended levels, the need for this type of after-sales service dried up. However, in the 1980s Roche and BASF leveraged their large product portfolios by developing networks of premix plants to serve agricultural producers and feed manufacturers. Sales of these premixes may have involved after-sales technical advice. A survey of this issue by the UK Competition Commission found that a few premix customers found customer support important in choosing a supplier (UKCC 2001: 13); however, the Commission later concluded that competition between suppliers of bulk vitamins "… is primarily on price" (*ibid. p. 16).* The European Commission is of the same opinion (EC 2003).

Entry Conditions

Getting access to the sophisticated synthetic chemistry needed to produce most vitamins is difficult. That and mastering the implementation of large scale manufacturing of vitamins appear to be the major barriers to entry. Entry is slow and impeded by sunk costs and excess capacity. A report of the European Commission summarized technical barriers from an internal 1972 memorandum by Roche:

> "Mass production of synthetic vitamins …requires heavy investment, since the synthesizing process is in large measure unique to each group of vitamins and highly specialized equipment is necessary. Plants used for manufacturing vitamins of one group cannot therefore be used for producing vitamins for another group, nor is the conversion of [a] plant for such production a simple matter…[P]roductive capacity is normally geared to the estimated growth in demand over 10 years…At present there is surplus capacity throughout the world for the production of vitamins" (EC 1976: 2).

Technological impediments vary somewhat across vitamins. Actual entry patterns reveal differences in the height of entry barriers in the manufacture of vitamins (Table 7). Producing the "oil-soluble" vitamins A, B3, D, and E seems to present the greatest difficulties for entry because they are still largely in the hands of the original producers, Roche, BASF, and Rhône-Poulenc; the same appears to be true for beta carotene and canthaxanthin. A somewhat lower degree of technological barriers to entry is revealed by production by Japanese chemical companies. Although evidence is spotty, Takeda, Eisai, and Daiichi seem to have begun producing vitamins B1, B2, B5, folic acid, and biotin a decade or two later than the big three European pioneers.[43] The more moderate barriers for these B type vitamins can be inferred by the less advanced state of Japanese pharmaceutical and organic-chemicals R&D up to the 1950s; however, by the 1970s the general scientific prowess of Japanese research had caught up to U.S./Western European levels in most fields.

Finally, there are a few cases of vitamins where more recent entry has occurred on a large scale in newly industrializing countries with relatively backward scientific infrastructures.

[43] In the case of vitamin H (biotin), the Japanese entrants were Tanabe and Sumitomo, each with about 20 percent of the world market.

The case of China in the 1980s and 1990s is particularly instructive, because the Chinese government has made investment in chemical industries with high export potential a high priority. Rapid rates of growth in Chinese exports of certain vitamins may be taken as an indicator that *technological* barriers to industry entry are fairly modest, especially access to knowledge about the synthetic chemistry required to implement feasible manufacturing methods. Thus, in those cases where Chinese vitamin exports were becoming competitive in the same markets to which the major European producers also exported, one can safely assume that patents or technological secrecy no longer protect the primacy of the established pioneer firms. There were six vitamin markets with large or growing Chinese exports to the United States in the 1990s: vitamins C, B1, B2, B6, B12, and folic acid. China's vitamin C imports were especially large, accounting for 54 percent of the value of total U.S. imports in 1996; B12 was next with 27 percent. The other four B vitamins were in the 8 to 13 percent import-penetration range, but growing. It is noteworthy that these are almost the same vitamins with significant Japanese production (B12 is the exception). However, there is little evidence of large-scale Chinese entry into synthetic production of vitamins A, E, B3, D, K, or – all markets supplied nearly exclusively by the pioneering, mostly European manufacturers. Therefore, technological barriers to entry appear to remain high for this last set of vitamins.

Table 8 provides additional specificity on the technical sources of possible barriers to entry into the manufacture of bulk vitamins. First, most of the vitamins made by chemical synthesis require chemical intermediates that are not available for purchase on open markets. These inputs must either be made as captive supplies by the vitamin maker, or they must be obtained from the one or two feasible local sources under long term supply contracts. In the first case, a potential entrant will incur additional sunk investment costs beyond those needed for vitamin production itself. An extreme example of this barrier is the fact that trimethylamine (TMA) is a key ingredient in making choline chloride. The major vitamin makers do not produce choline chloride because they do not have easy access to TMA. In the second case, suppliers are likely to have a profitable relationship with one of the established vitamin manufacturers that the supplier is loath to endanger by supplying a new rival. Second, several vitamins are made under synergistic conditions of production. Entrants that do not intend to make two or more of the synergistic products will suffer cost disadvantages relative to multiproduct established firms. Very few vitamins have neither of the two technical impediments to entry.

The major significance of these suggestions about technological barriers in understanding the evolution of vitamin price fixing is the fact that the Chinese exporters were spoilers for the cartels. The Chinese vitamin companies were too small, too numerous, and too inclined to be aggressive about exporting – all characteristics that made them unsuitable candidates to recruit to the vitamins cartels. Whenever Chinese chemical companies could adopt production methods that made their vitamin production price-competitive (assisted by Chinese government export subsidies), they aggressively captured U.S. market shares that in some cases were so large that the cartels affected were unable to sustain their conspiracies. This certainly happened in the case of vitamin C around 1995. Chinese incursion into the U.S. market was also one factor for the early demise of the cartels established in vitamins B1, B2, B6, B12, and folic acid.

Table 7. Evidence of Technological Barriers to Market Entry into Vitamins, 1990s.

High Barriers: Big Three Pioneers in 1980s Still Dominated Global Production [a]	**Moderate Barriers**: Pioneers No Longer Dominate but Little Fringe Firm Entry	**Low Barriers**: Chinese Exports Were High at End of Cartel [b] (Share of World Supply)	
A	B2	C	(34)
E	B12	B1	(40)
B3	Biotin	B6	(43)
B4		Folic Acid	(34)
B5			
D3			
Beta carotene			
Other carotenoids			

a) For A, E, and carotenoids pioneers were Roche, BASF, Eisai, and Rhône-Poulenc; for B3 Lonza, Nepera, and Degussa; for B4 Mitsui, Chinook, and DuCoa; for B5 Roche, Daiichi, and BASF; and for D3 Roche, BASF, and Solvay. Dominance is indicated by global production shares of 80% or more at the end of the collusive period (see Appendix Table 6).
b) In every case, there was earlier entry by Japanese chemical companies as well; cartels established in the early 1990s disbanded in late 1994 or late 1995.

Table 8. Key Chemical Ingredients Required for Vitamin Synthesis		
Vitamin	Intermediates Not Readily Available in Markets/ Other Sources of Technical Barriers	Raw Materials
E, synthetic	isophytol, trimethylhydroquinone, synergies with making vitamin A	acetone, acetylene, isobutylene, napha, formaldahyde
A	Pseudoionone, synergies with making vitamin E	acetone, acetylene, isobutylene, butenediol, formaldahyde
C	sorbitol	glucose
B4	Trimethylamine (TMA)	hydrochloric acid, ethylene oxide
Beta carotene	synergies with vitamins A and E	acetone, ocetylene, triphenylphosphine
B5	pantolactone, beta-alanine	isobutryaldehyde, bydrogen cyanide, hydrochloric acid, acrylonitrile, ammonia, caustic soda, calcium hydroxide
B3	methylglutaronitrile, beta picoline, 3-cryanopyridine, methylethylpyridine	ethylene, nitric acit, farmaldyhyde, ammonia
B2, fermented		sugars
B2, synthetic	ribose	
Biotin (H)	thiolactone	furnaric acid or diketene, cysteine, thiophene, phosgene gas
B1	synergies with A, E, B3, or beta carotene; grewe diamine	ethylene, prymidine, malononitrile, acronynitrile, carbon monoxide, acetamidine, butyroloctone, methyl acetate, hydrochloric acid, ammonia, carbon disulphate
B12, fermented		sugars, nitrogen compounds
B6		oxazole, dienophile
Canthaxanthin	beta carotene	15-carbon compounds
Astaxathin	canthaxanthin	15-carbon compounds
D3		cholesterol
Folic Acid (B9)		acetone or acrolein, chlorine gas, guanadine, cyanoethyl acetate, sodium ethoxide, nitric acid, hydrogen gas, glutamic acid, benzoic acid
Source: Bernheim (2002a: 34-58) and trade magazines.		

Summary of Structural Conditions

Most of the bulk vitamins industries were highly concentrated on a global level and had severe barriers to entry due to technological secrecy, market foreclosure of key inputs, or economies of scale or scope in production.[44] Not counting an unknown number of small but aggressive Chinese vitamins manufacturers, the typical vitamin industry comprised from two to five companies that controlled more than 95% of worldwide output. Combined with the undeniable homogeneity of the products, these are the archetypes ripe for formation of durable collusive arrangements.

Few of the vitamins industries do not quite reach these monopolistic standards.

COMPANIES

Major Players

Prior to World War II Hoffmann-La Roche dominated global production of most vitamins.[6] Rhône-Poulenc, Takeda Chemicals, Hoechst, and a number of smaller European and Japanese chemical companies entered in the post-World War II period. By the late 1980s, the "Big Three" manufacturers of vitamins (Roche, BASF, and Rhône-Poulenc) would control 60 percent of world production. They would become the core of the global vitamins cartels of the 1990s. This section provides brief sketches of their histories, strategies, and financial conditions.

Hoffmann-La Roche

The company began as a partnership founded in Basel, Switzerland in the late 19th century to manufacture medicines. Roche also began to invest abroad quite early in its history. Its first U.S. branch was opened in 1905.[45] By the advent of World War I, Roche had developed a successful portfolio of products that were sold on four continents. Although it began to sell shares to the public in 1919, the majority of the company's stock has been retained by the heirs of the five founding families.

Roche invested heavily in research and development from the beginning. In the 1960s Roche began marketing two important tranquilizers, Librium and Valium, which became a major source of profits. Around 1973 a British employee of Roche revealed an extraordinary level of

[44] The premix business had different types of barriers: availability of a complete array of bulk vitamins, mastery of the science animal nutrition and least-cost rations, an ability to offer custom blends tailored to specific customers, and a sales force trained to offer after-sales technical advice.

[45] Its foreign investments came in handy during World War II. Like some other Swiss multinationals, such as Nestlé, Roche transferred most of its assets to a North American holding company in case Switzerland was overrun. Roche's CEO moved to its U.S. headquarters in Nutley, New Jersey during the war to direct the company's operations not already in the hands of the Axis Powers.

geographic price discrimination across Europe for its tranquillizers.[46] An investigation by the UK Monopolies Commission determined that Roche's UK subsidiary was required to pay fifty times the price of the tranquillizer in Italy. The Monopolies Commission ruled against Roche, and required the company to reduce its UK wholesale price by 60 percent and to compensate UK buyers.

Roche had also run into antitrust trouble with the European Commission in the mid 1970s concerning its bulk vitamins business. In a decision made in June 1976, the EC charged Roche with a violation of the European Community's rules on abuse of a dominant position; Roche was fined the then substantial amount of €300,000. The EC found that Roche had imposed unreasonable restrictions on contracts with a large number of food, feed, and pharmaceutical manufacturers. In particular, Roche had gave substantial (up to 20%, but most much lower) rebates to customers that agreed to buy all of their bulk vitamins from Roche; further, the contract stipulated that its customers were required to report offers of other manufacturers of prices lower than Roche's prices. These contract terms were effective in preventing Roche's rivals like BASF from expanding through price cutting. It also discouraged E. Merck from expanding its vitamin processing capacity.

Roche's patents on the two tranquilizers expired in 1985, and its failure to find any exceptional new drugs in the 1980s began to place pressure on the company's profits. Adding to the company's woes were losses in market shares in two other major product lines: vitamins and citric acid. Chinese manufacturers were making significant inroads into these industries in the late 1980s, a trend that accelerated in the 1990s.

However, Roche was a financially strong company in the late 1990s. In 1997, Roche had global sales of $12.9 billion, of which almost two-thirds is pharmaceuticals. Roche is the fourth largest drug company in the world. The remaining third of its sales is spread across flavors and fragrances, vitamins, carotinoids, citric acid, enzymes, and genetic-engineered products. Roche manufactured vitamins in 11 factories around the world in Europe (6), the United States (3), and Asia (2). Vitamins and carotinoids accounted for 72% of the 1998 sales of Roche's Vitamin and Fine Chemicals Division (EC 2001: ¶77). The Division accounted for 14.7% of the company's sales. Thus, vitamins, in the last full year of the cartels, were 10.6% of Roche's sales.[47] In fiscal 1997, Roche was very profitable. Its net income was 22.8 % of sales. Bloated by two as yet uncovered price fixing conspiracies, Roche's Vitamins and Fine Chemicals Division had an operating profit of 18.5 % of sales.

BASF AG

BASF was founded in 1865. Its first successful products were dyes produced synthetically from coal tar. BASF grew quickly in the early 20th century. In 1910, the company employed 8,000 workers at its huge complex at Ludwigshafen near Hanover. By 1926, the plant covered 2,787 acres and employed 26,000 people. This plant was and remains the largest chemical manufacturing site in the world.

In 1904, BASF joined with the huge chemical company Bayer and many smaller German chemical companies to form a full-blown cartel in numerous lines of chemicals. Besides setting prices, the BASF-Bayer cartel enforced production quotas for each of its members, forced vertical integration among its members, engaged in predation and full-line forcing against rivals outside Germany, and pooled its profits. In the same year, Germany's largest chemical

[46] The whistle-blower's name was Stanley Adams. He was jailed by Swiss authorities for revealing Roche's trade secrets. Adams (1984) wrote a book about this episode. However, Adams came to a bad end. In 1994, he was convicted of conspiring to murder his wife for the insurance money (Barboza 1999).
[47] At more competitive prices in 1999-2000, it had vitamins sales of $1.5 billion, which comprises almost 9% of company sales (Bernheim 2002a: 62).

company, Hoechst, and most of the rest of Germany's chemical companies formed a second similar cartel. In 1924-1925, the two German chemical cartels extended their dominance of the world's chemical industries by merging into one giant cartel called I.G. Farben. This new cartel continued and refined the monopolistic practices of its predecessor cartels. I.G. Farben was larger than the three largest chemical companies outside Germany combined: DuPont, Imperial Chemical Industries, and Rhône-Poulenc. Beginning in the early 1930s, I.G. Farben began secretly helping Germany re-arm. As a result of active collaboration with the German war effort, I.G. Farben's directors were indicted, tried, and found guilty of war crimes at the Nuremberg trials in 1946.[48] In 1947, I.G. Farben was dismantled by the Allied occupation authorities. However, BASF, Bayer and Hoechst were essentially recreated in their pre-war images.

BASF made a rapid recovery after 1947. By the 1960s, BASF had become a world leader in dyes, petrochemicals, plastics, synthetic fibers, coatings, and agricultural chemicals (including vitamins). BASF's rapid growth continued up to 1989. In that year, BASF earned a profit rate on sales of 9.5%. However, 1989 proved to be a peak year, with sales and profits falling each year for four years thereafter. Employment, which had reached 137,000 in 1989, contracted to 104,000 by 1994. Besides massive layoffs, BASF divested itself of many operations (primarily in Europe), directed most of its new investments to East Asia, and made biotechnologies a high priority. From 1994, things began to improve at BASF. Sales, profits, and profit rates rose once again. By 1997, sales had reached $31 billion, and profits were back up to about 8 percent of sales. Indeed, by 1997 BASF edged slightly ahead of its two historically bigger rivals, Bayer and Hoechst.

BASF operated six plants that made 11 vitamins, two in Europe, two in Latin America, and two in Asia. In 1999-2000 BASF sold $541 million in vitamin products, which was about 2% of company sales (Bernheim 2002a: 63).

Rhône-Poulenc SA

This company traces its roots to two French companies. Ets. Poulenc-Frères began in Paris in 1858 as a maker of household cleansers, but turned to pharmaceuticals in the late 19th century. Rhône was started in Lyon in 1895 as a manufacturer of dyes and fragrances. The two firms merged and took their present name in 1928. During the Second World War, Rhône-Poulenc became a leader in nylon and penicillin. Rapid post-war growth made the company France's largest industrial enterprise by the late 1960s.

However, a number of poor business decisions in the 1970s combined with the poor performance of the French economy brought Rhône-Poulenc to the brink of bankruptcy in 1980-82. The French government nationalized the company in 1983 and sold off its assets in petrochemicals and agricultural chemicals. By 1993, when Rhône-Poulenc was privatized once again, it was drawing on foreign markets for 75 percent of its sales. By the 1990s, Rhône-Poulenc had become a big, diversified chemical manufacturer that made moderate profits in most years (pre-tax profits of 5 to 7 percent of sales). However, overall sales in the decade stagnated at around $15 billion per year. In 1998, Rhône-Poulenc and Hoechst announced plans to merge into a new entity called Aventis. This new company with its general headquarters in Strasbourg, France became a reality in December 1999. Aventis' life-sciences division is the largest in the world.

[48] When Germany occupied Czechoslovakia, the country's chemical assets were given to Farben. This scenario was repeated in Poland, Holland, Belgium, France, and other overrun countries. I.G. Farben built at least two chemical plants that were staffed with slave labor from concentration camps.

Rhône-Poulenc sold $516 million of feed-grade bulk vitamins in 1999, about 3% of Aventis' total revenue. Both of the company's vitamin plants are located in France.

Takeda Chemical Industries

Takeda was the Japanese pioneer in making and selling vitamins. By the 1980s it had become Japan's largest research-based pharmaceutical firm. In 1990, from factories in Japan and North Carolina, Takeda maintained leading production positions in four bulk vitamins. In 1999-2000, the company sold $686 million in vitamins worldwide, which represented more than 8% of its total revenues (Bernheim 2002a:65). Takeda would become the key link between the European members of the vitamins cartels and the six other Japanese manufacturers that joined the conspiracies.

Minor Players

The top four companies each generated well over half a billion dollars in vitamin sales in the year after the cartels of the 1990s ended. Below them were arrayed 17 smaller companies with fewer vitamin product lines; five are based in Western Europe, five in North America, and five in Japan.

Headquartered in Europe were E. Merck KGaA, UCB SA, Akzo Nobel NV, Degussa AG, Hoechst AG, and Solvay SA. **E. Merck**[49] is a private German chemical maker with a single plant that made vitamins E, biotin, C, and B6 during the 1990s. Merck had made several forays into various vitamin businesses in the 1980s. It made vitamins C, B6, and biotin throughout most of the 1980s and produced vitamin B2 until 1984. However, although Merck stopped manufacturing vitamin B6 from 1992 to 1997, it continued to sell purchased material until it resumed production in 1998. **UCB** is a large Belgian chemical manufacturer with choline chloride plants in Belgium, Germany, and Spain. Dutch chemical company **Akzo Nobel** also made choline chloride in plants in the Netherlands, Italy, and China. (Europe's third choline chloride maker is BASF). **Degussa** is Germany's third largest chemical concern; it makes vitamin B3 in its Belgian plant. **Lonza**, headquartered in Basel, Switzerland, is partly owned by the large Swiss aluminum maker, Alusuisse. Lonza is the world's largest producer of vitamin B3, which is made in its plants in Switzerland, China, California, and Pennsylvania. Lonza also manufactured biotin from 1990 to 1996. Finally, **Solvay** is a Belgian firm with the leading position in vitamin D3, which it makes through an affiliate in India.

In the North America there are five companies that only manufacture vitamins B3 and choline chloride (B4). **Nepera**, Inc., a subsidiary of Cambrex Corp. of New Jersey, produced vitamin B3 in its sole plant in New York State. **Reilly Industries**, Inc. manufactured vitamin B3 in its Indiana plant through Vitachem, a joint venture with Degussa; Vitachem also seems to have operated a Belgian plant until it was dissolved in December 1998.[50] **DuCoa** was a joint venture of the ConAgra and DuPont companies devoted to making vitamin B4 in Missouri, South Carolina, and Mexico; In August 1997, DuCoa was acquired by its management under the name DCV. **Bio-Products**, Inc. is the second vitamin B4 maker with production facilities in Louisiana, Kentucky, and Brazil. Bio-Products is a subsidiary of the Tokyo-based trading company Mitsui & Co. **Chinook Group** of Toronto, Canada manufactured vitamin B4 in Ontario, Minnesota, and Singapore.

[49] E. Merck is the former parent of the now much larger U.S. pharmaceutical manufacturer Merck & Co.
[50] The small Belgian plant is still operated by Reilly. Whether it is the same Belgian B3 plant owned by Degussa is not clear.

Besides Takeda and Mitsui/Bio-Products, five other Japan-based manufacturers joined the global vitamins cartels of the 1990s. **Daiichi** Pharmaceutical Company made vitamins B5 and B6 in its two Japanese plants. In 1999-2000, Daiichi sold $88 million worth of bulk vitamins, about 3% of its total revenues. **Eisai** Company made only vitamin E in its Japanese and Texas plants. **Sumitomo Chemical** manufactured biotin and folic acid in its Osaka plant; its participation in these cartels ended in the spring of 1994. **Kongo Chemical** also withdrew from fixing the price of folic acid in mid 1994. Finally, **Tanabe Seiyaku Company** was another Osaka manufacturer of vitamins; it ceased production of vitamin B2 in 1991, but in most years it was the second-largest producer of biotin. Because Sumitomo, Kongo, and Tanabe ceased colluding more than four years before the first indictments were handed down, none was fined by antitrust authorities.[51]

Fringe Firms

At the beginning of the 1990-1991 cartels, the fringe controlled 7% of world vitamins manufacturing production (Bernheim 2002a: Chapters 7 and 8). Fringe firms are those that produced cartelized products but did not join actively the cartel agreements. In some cases, fringe producers acted passively in support of the cartel by raising their prices along with the cartel and restraining their output.[52] In other cases, fringe producers behaved opportunistically by under pricing the cartel expanding their output when prices were high. Aggressive increases in market shares by fringe producers appear to be the main explanation for the early termination of four or five of the vitamins cartels.[53]

The most important part of the fringe that explains the dynamics of vitamin cartelization is about 50 Chinese chemical companies. Whenever these firms were able to master the techniques of production and produce a vitamin at a competitive price, they expanded output rapidly and exported vitamins in large quantities. The more effective the vitamins cartels were in raising world prices, the faster Chinese manufacturers captured market shares (Appendix Table 6). In the first years of exporting the quality of Chinese vitamins made them unsuitable for human consumption in the high income importing countries, so helped by government export subsidies they focused at first on entering feed-grade channels at discounted prices. In the late 1990s, some European and Japanese vitamin manufacturers formed joint ventures with leading Chinese exporters, whereby Chinese producers got access to equipment and expertise to purify their bulk vitamins. By the late 1990s the purity of Chinese made vitamins had improved but government subsidies had been reduced or withdrawn. When prices collapsed in most vitamin markets in 1999-2002, the global share of Chinese product also fell.

Clarke and Evenett (2003: 700) chart the growth of exports of vitamins from China. Measured in 2002 dollars, the value of these exports was between $25 and $50 million in 1985-1989. These exports were not enough to undermine the cartels operating in the late 1980s.

[51] Although saved by the statute of limitations from government fines, they were defendants in civil actions in the United States where plaintiffs asserted fraudulent concealment. The European Commission decision identifies the three as active members of the two cartels.

[52] This form of followership is termed umbrella pricing; although such parallel conduct harms buyers it is generally not held to be illegal behavior when there is no evidence of overt communications with members of a cartel. It is possible for a given firm to be both a conspirator and a fringe firm. For example, E. Merck explicitly colluded in the vitamin C cartel, but because of its insignificant market share remained in the fringe of the vitamin E cartel.

[53] One borderline case is vitamin E. Production in China began in 1991 but stayed below 3% of world production until 1997 and 1998 when its share rose to 7% and 11%, respectively. Only modest price effects can be noted in those years.

However, as soon as market prices began to rise in 1990-1991, Chinese exports doubled. From 1991 to 1995, Chinese exports rose at an average annual rate of 37%. By 1995 or 1996 Chinese exports almost single handedly destroyed four of the global cartels. In the late 1990s this torrid growth paused but total exports remained near the 1995 peak of $350 million.

Chinese producers had a profound impact on the termination of the vitamin C cartel in 1995. They already had a 3% global share in 1980 that grew to 8% by 1990. As the vitamin C cartel was getting underway in 1991, Chinese manufacturers were adopting a new low-cost fermentation technology that put them in a formidable price position. Chinese production tripled between 1991 and 1994, the peak year for vitamin C prices. Moreover, during the last difficult year of the cartel as prices plummeted, China's vitamin C manufacturers added an unprecedented 10 percentage points to their global market control. Unlike the other cases in which Chinese output expansion sapped the ability of cartel members to maintain high prices, in vitamin C China retained its high share of world production years after the cartels was abandoned.

There are three other vitamins cartels where aggressive Chinese growth seems to have been the primary reason the collusive groups lost their grips on the markets. First, in the case of vitamin B1, Chinese incursion into this market was already significant in the 1980s, with a global share ranging for 9% to 14% during the decade. When collusion began in 1991, the high prices caused Chinese manufacturers to ramp up output very quickly. From 1990 to 1994, the last year of the cartel, China's production grew an average of 35% per year; as a result, its global market share rose fro 12% to 40%. However, when prices plunged by 40% from early 1993 to 1998, China's share fell back to below 30% while the shares of the cartel members bounced back. This seems to indicate that costs of production in China were not dramatically lower than those of Roche and Takeda.

Second, in the folic acid (vitamin H) industry, China's share of world production in the 1980s languished in the 2 to 3% range. Collusion began in 1991 and by the time the cartel reached its apogee of pricing effectiveness in 1993-1994, the Chinese had captured one third of global production. However, as folic acid prices crashed by 55% over the next five years, the share of Chinese factories stabilized at around 20%. The folic acid industry is one of the few in which Chinese expansion was paralleled by long term growth of small Indian vitamin manufacturers.[54] India's global share reached 7% in 1994 and rose to 9% four years later. Finally, in vitamin B6, the Chinese did not enter the market until 1986 and achieved only a 4% share of world production by 1990. However, as soon as the cartel raised prices in 1991, the Chinese fringe increased that share by 250%; in the cartel's last year (1994) Chinese producers accounted for an astounding 43% of world supply. This impressive tenfold surge in share of supply was the largest of the four markets discussed in this section. Alas, it was short-lived; with the end of high prices the Chinese industry fell back to a mere 10% of global production by 1998.

There were a number of non-Chinese vitamin makers with significant production shares, but only one that may have hastened the demise of a cartel in the 1990s. Archer Daniels Midland Company grew quickly in the vitamin B2 market through the application of a new fermentation technology.[55] ADM's 5% share at the end of the vitamin B2 conspiracy in 1995

[54] Anonymous Indian firms made fitful and brief forays into the synthetic vitamin A, C, and B1 markets in the 1990s, but none proved sustainable. Indian companies frequently supply small amounts of naturally extracted vitamins to major industrial countries.

[55] ADM entered the vitamin B2 industry through the purchase of Zeagan (formerly Coors Biotech), a subsidiary of Adolph Coors Company of Colorado. Zeagan had developed the fermentation technology and had produced vitamin B2 in a Kentucky plant from 1989 to 1993 during which time its worldwide production share had grown from 1% to 5%. ADM moved production to its Illinois plant in or shortly after 1993.

grew to 12% three years later. Chinese producers tried to enter the vitamin B2 industry in 1985, but were forced to withdraw in 1993. In all other vitamins industries, non-Chinese fringe firms with significant market shares appear to have been passive followers or constrained by capacity.[56]

MARKET SIZE AND GROWTH

The sizes of the major vitamins markets varied considerably. Overall, however, the sales of the 16 vitamins and carotenoids that were affected by cartels were far greater than any other price-fixing conspiracies uncovered by antitrust authorities in the mid 1990s. Estimates of annual vitamin sales are shown for the world and four regions in Table 9.

Global sales of bulk vitamins sold "straight" were $3.1 billion per year.[57] Another product that was subject to price fixing in the 1990s was feed premixes.[58] Premix sales are very large, but are known with some precision only in North America. Counting premix sales, Vitamins, Inc. garnered annual worldwide sales of $4.2 billion. As will be discussed below in greater detail, the vitamin cartel endured for as little as three and one-half years and as long as ten years.

For the entire affected periods of the 1990s, total sales in nominal dollars amounted to $26.9 billion (Table 9A). Some of the vitamins markets may have been cartelized in the late 1980s, and their affected sales then were $7.0 billion. During the cartel periods, sales in the U.S. market accounted for about 28% of the global total and Canada for an additional 1.9%. In the U.S. market, three types of direct buyers may be distinguished. The largest share of U.S. sales was several thousand buyers that were members of the federal class action against the vitamins defendants. Most of the 143 largest purchasers opted out of the federal class action and filed separate suits. Western Europe accounted for 36% of global sales. Perhaps surprisingly, a large number of buyers representing 31% of U.S. sales did not sue the defendants. [59] Buyers in Asia, Africa, and Latin America purchased 35% of the cartelized vitamin products. One reason for the large global shares of Europe and North America is the fact that about half of the value of vitamins sold are for animal-feed use, and consumption of grain-based feeds for meat, poultry, and aquaculture production is especially intense on those continents. Animal husbandry in other parts of the world tends to depend more heavily on pasture grasses. It is likely that vitamins sold for food and pharmaceutical uses follow human populations more closely. That is, relative to feed-grade, human-grade vitamins have higher geographic shares in Asia, Africa, and Latin America.

Vitamins A, C, and E are by far the largest of the bulk vitamins markets, accounting for 42 percent of total vitamin sales worldwide. Seven more vitamins and carotenoids had average

[56] For example, Japan's Alps Pharma maintained a 6% to 10% global share during the vitamin B5 cartel, but its share was declining both during and after the cartel ended, so it appears to have played a weak role if any in the demise of this cartel. Unknown Eastern European suppliers were more responsive to high vitamin B5 prices in the late 1980s and mid 1990s, with there shares of production reaching as high as 9%. Korea's E-Sung produced biotin starting in 1989; while its global share rose to 7% at the end of the cartel in 1994, its position shrank when prices fell thereafter.

[57] "Straight" vitamins are unblended product forms; the internal sales records of the largest vitamins makers use the German term "tel quel." Straight vitamins included in premixes manufactured by the vitamins defendants are included.

[58] Sellers were convicted criminally and in civil actions of fixing the prices of feed premixes in Canada and the United States, but as of 2005 not in any other jurisdiction. Documents are not clear as to whether food-fortification premixes were cartelized. Affected sales of these products are approximate.

[59] Some of these were loyal customers privately compensated by the defendants.

annual sales of at least $100 million per year in the 1990s. The smallest global vitamin markets are for folic acid and vitamin D3.

Vitamin markets in the 1990s could be described as mature. As recently as 1960-1975, the markets for bulk vitamins had seen their volumes expand by 10% per year (EC 1976). The average rate of volume growth worldwide for all vitamins in the mid-1990s was down to 2% to 3% per year. Only vitamins E and B5 (Cal Pan) could be described as growing rapidly, and this might be due to temporary factors such as recent publicity about the health benefits of antioxidants (including E and C).[60] Most vitamin markets displayed negative or nearly zero volume growth in the 1990s. Rates varied across marketing channels as well, with cosmetic use of vitamins the fastest growing.

Mark-ups in vitamins sold for human use at retail tend to be very high. Thus, there is often a great discrepancy between vitamin sales at the manufacturers' "bulk" level as shown in Table 9 and sales at retail. Vitamins sold for feed use are incorporated into premixes sold to feed manufacturers or farmers that raise animals. The price of feed-grade vitamins is eventually reflected in the prices paid by consumers for meat, poultry, eggs, milk, and farm-raised seafood. A similar mark-up from bulk vitamin prices occurs in the case of fortified foods (milk, flour, pasta, etc.). The mark-ups for feed- and food-grade vitamins are fairly modest in comparison to pharmaceutical grades. In the late 1990s one reliable study placed the size of the *retail* U.S. consumer market for pharmaceutical vitamins at $5.8 billion. Bulk pharmaceutical-grade bulk vitamin sales at that time cannot have been more than $400 million. Therefore, by the time consumers bought packaged vitamins in their grocery and drug stores, the mark-up on manufacturers' prices was an astounding 1,350 percent. Put another way, only about 7% of the retail purchase price of vitamins by consumers can be attributed to the cost of the raw vitamins, the rest being accounted for by advertising, packaging, assembly, and distribution costs.[61]

[60] Epidemiological studies released in the 1980s appeared to demonstrate reductions in heart disease and certain types of cancer associated with consumption of vitamins A,C,E, and B3; but controlled experiments with human subjects a decade later failed to find any positive health benefits.

[61] During the vitamins conspiracies of the 1990s, which lasted four to eleven years, consumers probably spent $35 to $40 billion directly on vitamins at retail. However, assuming an overcharge on bulk vitamins of 30 percent and a 100 percent pass-through, consumers were overcharged about $350 million, but that is only 0.9 to 1.1 percent of the value of retail purchases.

Table 9. Annual Sales of Bulk Vitamins, mid 1990s Collusive Periods

Product	United States [a]	Canada [b]	Western Europe [c]	Rest of the World [d]	World [f]
			Million nominal U.S. dollars		
A	89.6	6.3	165.1	70.8	436.0
B1	14.3	2.0	26.0	19.8	62.1
B2	27.6	2.2	52.0	20.7	102.5
B3 Niacin	42.7	1.3	40.0 [e]	41.6	125.6
B4 Choline	43.3	4.5	54.9	88.0	190.7
B5	22.3	1.3	37.3	8.7	69.7
B6	13.4	4.3	18.3	25.8	61.8
B9 Folic acid	3.3	0.6	4.9	1.3	10.1
B12	14.0	0.3	18.8 [e]	25.4	58.4
C	205.4	14.4	256.7	314.2	790.7
D3	16.0 [e]	1.1 [e]	21.8	14.4	53.3
E	180.0	12.1	236.6	86.0	515.0
H Biotin	56.7	0.8	36.0	68.7	162.2
Beta carotene	56.0	3.4	81.6	28.7	169.6
Carotinoids, other	21.1 [e]	0.2	89.1	190.9	301.3
Subtotal	805.7	55.1	1139.1	1005.0	3109.1
Premixes	291.4	24.9	375.0 [e]	349.9 [e]	1041.1
Total	1097.1	80.0	1514.1	1354.9	4150.1

Source: Appendix Table 1, annualized by dividing by the guilty-plea period. Corrected 3/18/08.
a) Affected sales divided by plea periods; sales in the extended conspiracy period are 33.5% higher.
b) Affected sales divided by Canadian "conspiracy period".
c) Affected sales divided by EU conspiracy period. If not available, used U.S. dates.
d) Estimated as a residual.
e) Estimated as a proportion of more certain data available in other regions.
f) Data from Bernheim (2002a: 33) divided by mean of U.S. and EU conspiracy periods.

Table 9A. Affected Sales of the Vitamins Cartels, 1980s and 1990s				
Buyers	Late 1980s	1990's Plea Periods	Both Periods	
			Amount	Percent of World
	Nominal million U.S. dollars			*Percent*
U.S. Federal class	727.8	2985	3713	10.3
U.S. Direct action	634	2600	3234	9.0
Others	612	2509	3121	8.7
Total U.S.	1974	7555	10068	28.0
Canada	133	546	679	1.9
W. Europe	2513	8555	11068	30.8
Rest of the World	2429	11253	13682	38.1
Total World	7049	26909	35959	100
Source: Bernheim (2002a).				

TRADE AND LOCATION OF PRODUCTION

In the early 1990s the 21 members of the vitamins cartels of the 1990s owned 54 generally large vitamin production facilities that accounted for more than 90% of world production (Table 10). Twenty of these 54 plants were located in Western Europe, 19 in North America, 11 in Asia, and four in Latin America. In addition there were more than 60 generally smaller plants operated by fringe firms in China, India, Eastern Europe, and a couple of other places. Around 1990 these smaller plants supplied about 7% of world demand, but by the late 1990s they accounted for about 15%.

Western Europe, Japan, and China produced considerably more than was needed for consumption in those regions. Roughly speaking, those three regions manufactured about 40-54%, 20-25%, and 10% of the world's vitamins, respectively, yet they accounted for only about 50% of world consumption. Exports from those areas flowed to North America, Africa, Latin America, and other nations of Asia. North America imported about half of its demand (30% of the world's demand) and the rest of the world about three-fourths of the remaining 20%.

In the 1930s and 1940s, Merck, Squibb, Pfizer, Lilly, and other large U.S. pharmaceutical firms were early entrants into vitamin manufacturing. However, a survey of the U.S. International Trade Commission reveals that by the early 1990s there was very little local manufacturing of vitamins by U.S. companies. Two U.S. and one Canadian company made only vitamins B3 and B4. The major part of local production came from 14 U. S. plants owned by six non-U.S. chemical companies.[62] As a result, slightly more than half of all bulk vitamins sold in

[62] Roche was by far the largest producer of vitamins in the United States. It made vitamins A, C, E, H, and beta carotene in plants in New Jersey and Texas. The USITC survey records U.S. production of vitamins B1, B2, B3, B5, and B6 by Roche in New Jersey. Besides Roche, Takeda is the only large

the U.S. market in the 1990s originated offshore. Most U.S. imports came from Europe, Japan, or China – the home countries of the world's leading vitamin manufacturers.

Table 10. Plant Locations, Bulk Vitamins, 1990s

Company	Europe	Asia	North America	Latin America	Total No.
Roche	CH CH CH DE FR UK	JP CN	US US US		11
BASF	DE DK	CN	US	MX BR	6
Takeda		JP	US		2
Rhone	FR FR				2
Takeda		JP	US		2
Daichi		JP			1
Eisai		JP	US		2
E. Merck	DE				1
Akzo Nobel	NL IT		CA		3
Lonza	CH		US US CA		4
Hoechst	FR				1
Solvay		IN			1
DuCoa			US US	MX	3
Bio-Products			US US	BR	3
Chinook		SG	US CA CA		4
UCB	BL DE ES		US		4
Degussa	BL				1
Reilly	BL		US		2
Sumitomo		JP			1
Tanabe		JP			1
Kongo		JP			1
Cartel Total	20	11	18	4	54 [a]

Source: Bernheim (2002a: 62-80) and Connor (2001: 296-299).
a) Non-cartel manufacturers of bulk vitamins accounted for about 4% of world production from plants in the USA (2), Eastern Europe (4), Japan (3), Korea (1), and many small plants in India and China.

producer of vitamin C in the United States. Vitamin E is made synthetically by BASF in Michigan. Besides these two large producers, smaller amounts of natural vitamin E are being made by ADM in Illinois (since 1995), Henkel in Illinois, Eisai in Texas (since 1997), and by a Cargill joint venture in Iowa (since 1997).

THE VITAMINS CONSPIRACIES

Collusion Begins

Makers of organic chemical intermediates have one of the highest rates of cartel formation of any industry, and vitamins are organic chemicals (Connor and Helmers 2006). Nearly 100 international cartels were formed in the chemical industries in the early 20th century (Leiden University 2005). One of them formed in 1928 pooled patents and divided world exports in vitamin D (Hexner 1946:347-349). International cartel conduct is also more common among European and Japanese manufacturers than in North America. Because vitamins production was even more highly concentrated and more difficult to enter in the 1970s and 1980s than in the 1990s, it seems likely that overt collusion was practiced at least among firms within if not across the Western European and Japanese markets prior to 1990.

The plaintiffs in the civil suits in the United States appear to have had some direct evidence of illegal collusion on a global basis in most of the bulk vitamins markets in the late 1980s. What the nature of that evidence is not generally known.[63] However, plaintiffs' counsel instructed their chief economic expert to prepare damage estimates for two periods, the late 1980s and the better-known guilty-plea periods of the 1990s. The only evidence known to the present author comes from highly suspicious U.S. transactions price movements in most bulk vitamins markets beginning in 1985 or 1986 and ending in late 1988 or early 1989. These price patterns trace the "hump-shaped" pattern that is characteristic of effective collusive behavior. Moreover, the price humps are preceded by about four years of falling prices that are commonly observed prior to the formation of cartels. It appears that collusion may have broken down briefly prior to the more durable cartels that were renegotiated in 1990 or 1991.

These suspicious price patterns are observed in all the markets for oligopolistically structured vitamins markets except folic acid and B12 (Table 10A). In the oligopolies, prices declined on average 30% in the early 1980s, then rose 40% until 1989 or 1990, and fell once more about 12% in the year agreements for the 1990s were being hammered out. However, for three duopolies, only steady or increasing prices are observed throughout the decade of the 1980s. The three duopolistic industries consist carotenoids manufactured globally solely by Roche and BASF from 1980 to the late 1990s.[64] Roche, the original producer of synthetic carotenoids, slowly ceded a portion of its near-monopoly positions to BASF over the two decades. Because prices moved only upward from 1980 to 2000, it appears that Roche and BASF were extraordinarily cooperative in pricing conduct in these industries; that is, whether overtly colluding or tacitly colluding, pricing was practically at monopoly levels (Kovacic *et al.* 2006).

[63] Bernheim (2002a:) cites several documents obtained during discovery, some of them deposition transcripts, that appear to be direct evidence of agreements in the late 1980s.

[64] Sumitomo made beta carotene in the early 1980s, but never achieved more than 2% of global production before it withdrew in 1998. A fourth carotenoid, not sold in the United States, is Apocarotenal. It is also probably a duopoly.

Table 10A. Collusive Price Patterns in 1980-1991						
Vitamin Product [a]	Prices before Collusion		Prices during Collusion		Prices after Collusion	
	Time	Price Change	Time	Price Change	Time	Price Change
		Percent		*Percent*		*Percent*
Oligopolies:						
E	1981-6/85	-33	6/85-12/88	+39	1989	-25
A	6/81-12/85	-26	12/85-12/88	+61	1989	-14
C	1/82-6/86	-27	6/86-12/90	+36	1991	0
B5	6/81-12/85	-42	1/86-6/88	+67	6/88-12/90	-13
Niacin feed	6/81-12/86	-33	1/87-12/89	+56	12/89-6/90	-21
Niacin USP	6/81-9/86	-23	9/86-9/89	+33	9/89-9/90	-12
Niacinamide feed		0		0		0
Niacinamide USP	6/81-9/86	-23	9/86-9/89	+33	9/89-9/90	-4
B2	1/81-12/85	-27	1/86-6/88	+35	6/88-12/90	-13
Biotin feed	1/82-12/85	-27	1/86-6/88	+40	1/90-12/91	-30
Biotin USP	6/82-12/87	-48	1/88-12/90	+53	1/91-12/91	0
B1	1/82-12/85	-35	1/86-6/88	+49	6/88-1/90	-10
B6	1/81-12/85	-41	1/86-6/88	+52	6/88-12/90	-21
D3 feed	1/83-12/85	-37	1/86-12/88	+19	1/89-12/90	-11
D3 USP	No data	--	1/85-12/89	+25	1990	0
Mean	6/81-6/85	-30	1/86-12/88	+40	1990-91	-12
Duopolies:						
Beta carotene	1/80-1/88	0	1/88-12/90	+25	1/91-12/91	0
Cantha-xanthin USP	1/80-1/88	0	1/88-12/90	+17	1/91-12-91	0
Apocarotenol	1/80-12/87	0	1/88-12/90	+52	1991	0
Mean	1/80-1/88	0	1/88-12-90	+31	1991	0

a) No price data are available for choline chloride and folic acid. In addition, no collusion alleged for B3, B12, and premixes.

Global Cartel Connections

The initial financial success in raising the prices of vitamins A and E in 1990 prompted the formation of 12 additional cartels in 1990 and 1991.[65] However, there is considerable evidence to suggest that the effectiveness of the vitamin cartels inspired the formation of the

[65] As is explained below, the vitamin B3 and B4 cartels were organized before and separately from the 14 Roche cartels.

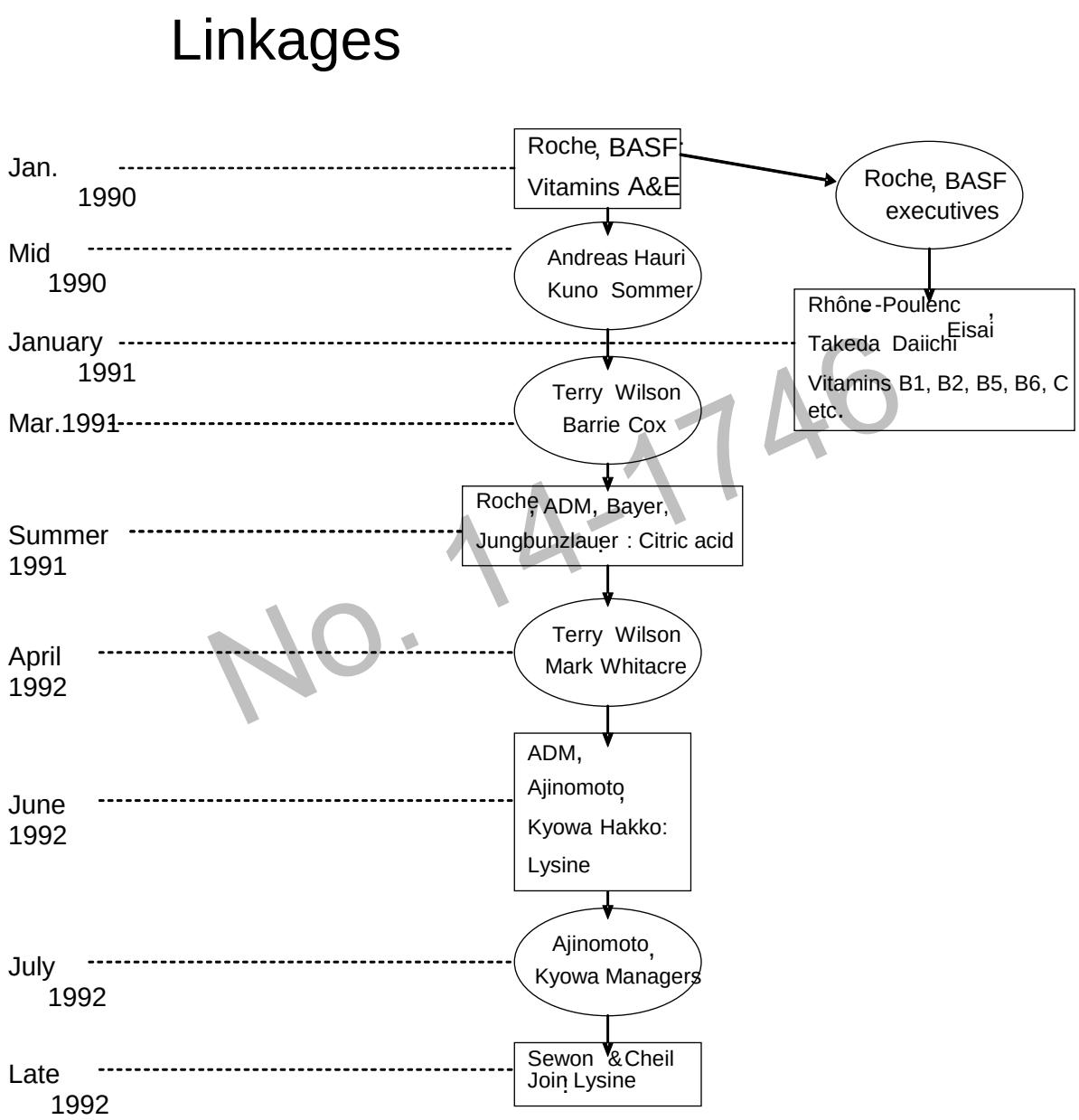
citric acid cartel a year later. Moreover, there is irrefutable evidence that it was ADM's satisfaction with its citric acid scheme that incited an ADM officer to start the lysine cartel less than a year after citric acid was under way. Not only is there enough information on which cartel spread the infection that caused cartel fever elsewhere, but also there is a fair degree of certainty about which companies and which persons were the carriers.

The causal chain of events linking the three global cartels is sketched in Figure 1. The time line begins with Hoffmann-La Roche and BASF getting together in late 1989 to begin colluding on the prices of vitamins A and E. The first price increases in A and E take effect in early 1990. Around this time, Kuno Sommer, head of Roche's Vitamins and Fine Chemicals Division, wrote an internal memorandum suggesting that Roche's experience with these two vitamins is so satisfactory that cartels should be explored for other products in his division. By late 1990, several other vitamin manufacturers had joined Roche and BASF in forming more vitamin cartels that are launched in January 1991.

More to the point, Sommer's colleague Andreas Hauri, Roche's marketing manager for citric acid, received an unexpected visit from top officers of the world's newest manufacturer of citric acid, ADM. The timing could not have been better. Roche and Hauri were primed to accept the emissaries' overtures to form a global cartel for citric acid. Within two months, the four largest global suppliers of citric acid came to a durable agreement to raise prices worldwide. One of the two ADM officers was Terrance Wilson, and he almost immediately began the search for cartels for other ADM products. Although Wilson considered some other food-and-feed ingredients to be good candidates for price fixing, lysine was one that has all the necessary characteristics.[66] In April 1992, Wilson took the young Mark Whitacre to Tokyo to meet with the largest suppliers of lysine (Ajinomoto and Kyowa Hakko) and began to mentor Whitacre in the craft of price fixing.

[66] It is known that Wilson explored establishing a cartel in lactic acid, a food acidulant similar to citric acid. Other products believed to have cartelized by ADM include monosodium glutamate (MSG) and sodium gluconate. Corn sweeteners and methionine are other possibilities.

FIGURE 1. Personal and Corporate Connections among Three Cartels



Origins in the 1980s?

It seems likely that many of the Roche cartels began colluding as early as 1985 (Bernheim 2002a). Sometime between mid 1998 and early 1999, prices of nine bulk vitamins made by more than two producers declined (Table 10A). The fall in prices stopped in either early 1990 (vitamins A, E, B1, B3, and B6) or in early 1991 (vitamins C, B5, D3, and biotin) and began to rise for several years thereafter.[67] What sparked these brief pauses in the upward movements in prices is not known, but these dips cannot be described as full-blown price wars that signal the end of collusion, because prices stayed well above costs of production. Rather, they appear to be the kind of mild disciplinary internecine skirmishes symptomatic of the need or desire to renegotiate cartel agreements (Levenstein 1997). Such occasional signals of discontent may well be necessary to mend and renew a cartel's harmony of purpose.

What is known about the cartels of the late 1980s is that there was turbulence within the cartels. Stress did not arise from entry by fringe producers.[68] Large changes in market shares among the participants may be evidence of cheating on quotas that had been agreed to as the cartels were launched. The usual method of negotiating a share agreement is to accept a pre-cartel share as the starting point; to attract smaller firms into the fold, the leader may resign itself to a modest erosion of its market share during the collusive period. In seven cases, the leader was Roche and it suffered sharp global share declines averaging 7.0 percentage points in about four years.[69] The spoilers of cartels discipline varied from cartel to cartel. Normally cooperative BASF grabbed market share in the vitamin B2, B5 and B6 cartels, and Rhone-Poulenc took six percentage points of the world vitamin A market. However, the most frequent disturbers of the peace were the Japanese members of the cartels; they aggressively acquired an average of 6.3 percentage points in seven cartelized vitamin industries.

Besides dissention within most of the cartels of the late 1980s, the need to renegotiate cartel agreements in 1989-1990 may be due to other challenges. One possibility is that decelerating growth rates and standardization of quality standards had led the vitamin business to evolve from its former specialty-chemical status to one more like a mature, commodity-type industry in which buyers focused solely on price during purchase negotiations.[70] Such an evolution would have squeezed profit margins for the producers, but ironically a movement towards greater homogeneity of quality would have made price fixing easier.

Another hypothesis about the timing of the vitamins cartels may be derived from the general financial conditions facing the prime movers of the conspiracies. Each of the major chemical companies (Roche, BASF, Rhône-Poulenc, and Hoechst) faced a financial crisis in the late 1980s that became public knowledge when their financial results were later reported for

[67] Besides price movements, the temporal analysis of public price announcements by Marshall et al. (2005) supports a shift to an explicitly collusive regime around 1995.

[68] In the eight oligopolistic markets where collusion is alleged in the late 1980s, the mean cartel control rose by 0.5 percentage points and the maximum loss was two percentage points.

[69] The industries were E, A, C, B5, B2, B6, and biotin and the time periods were from 1984to 1988 or 1989 (Bernheim 2002a: Chapter 8). In the vitamin B1 market, the loser was BASF (7 points). The vitamin D3 market was the only one in which the cartel's leaders gained shares during the allegedly collusive period.

[70] The biggest vitamin sellers maintain lists of scores of varieties of one vitamin, while smaller companies tend to have narrower lines. Some are available in liquid or dry forms, and most come in human and feed grades; these are significant functional differences. Some varieties differ according to the strength of the active ingredient, type of inactive ingredients if any, and packaging. Despite this apparent heterogeneity, from the point of view of pricing, there tends to be one most common product form for which price quotes are made. All other varieties are then priced off this model product form by means of conventional, customary premia or discounts.

fiscal years 1990 to 1994. Internal projections of poor sales or profitability would have been known to top managers of the companies in the 1988-1989 period. In some cases, profitable pharmaceutical products were losing patent protection. In other cases, one of the periodic bouts of overinvestment in fixed capital was hitting the chemical industry. For some the problems were overstaffing, inflexible labor markets, overcapacity, and unprofitable diversifications, particularly in the companies' core Western European operations. Compounding the companies' woes was the onset of a global recession in 1990, a downturn that lingered for several years longer in Western Europe than in other regions of the world. In Japan too, the miraculous growth that had characterized the post-war period had burst. Japan experienced a nearly zero-growth phase that was to persist throughout the 1990s. Desperate times produce desperate men, and the top managers of the world's great vitamins concerns would not be immune to desperate measures to restore profitability. Price fixing, though illegal for pharmacists to dispense, was a tonic that promised to restore the financial health of these companies' anemic income statements.

Major price increases announced by leading companies are usually faithfully reported by the chemical trade press.[71] The decade of the 1980s was generally a period of modest inflation for the U.S. economy; there were relatively few price increases announced for vitamins during that time. In any case, the announcements concerned only list prices. While smaller buyers might sometimes pay list for spot purchases, the largest companies sought bids for their purchases or negotiated annual supply contacts at prices well below list.

However, rounds of list price increases announced in late 1989 (effective January 1990) and early 1990 caused vitamin buyers to sit up and take notice. Market demand for many vitamins was described as flat and in early 1990 the first signs of a recession were appearing, so the timing of the price increases was curious. Rhône-Poulenc made the first "official" public announcement in November 1989, but other European producers were doing the same informally to their customers. The most publicized list-price changes came from Roche and BASF in early March 1990. Roche *raised* its list prices on both human-grade and feed-grade vitamins A and E, while BASF simultaneously *lowered* its list prices. The important result was that both leading producers' list prices now exactly matched. The March 1990 round was the first change in list prices since 1988. The two companies publicly admitted that during 1989 market transaction prices had hovered 20 percent below their list prices, but they promised that the gap would close during 1990. Indeed, the major purposes in the March 1990 changes were to close the gap and to increase margins. A more forthright, if brazen, statement can hardly be imagined.

Cartel Organization and Methods

The vitamins cartels resemble the innards of a Swiss watch. There were wheels within wheels (Figure 2).

Twenty-one manufacturers joined one or more of the conspiratorial groups that met to agree on prices and tonnage quotas, to monitor implementation, and to enforce those agreements. Of the 21 participants, 14 belonged to only one cartel, and seven belonged to multiple cartels. Hoffmann-La Roche was in 14 cartels.

Price fixing was arranged for at least 16 products: 13 bulk vitamins, two carotenoids, and feed premixes.[72] In all but two of these cartels Roche, BASF, or Rhône-Poulenc took the lead in

[71] The principal trade magazines are *Chemical Week*, *The Journal of Commerce*, and *Chemical Market Reporter.*

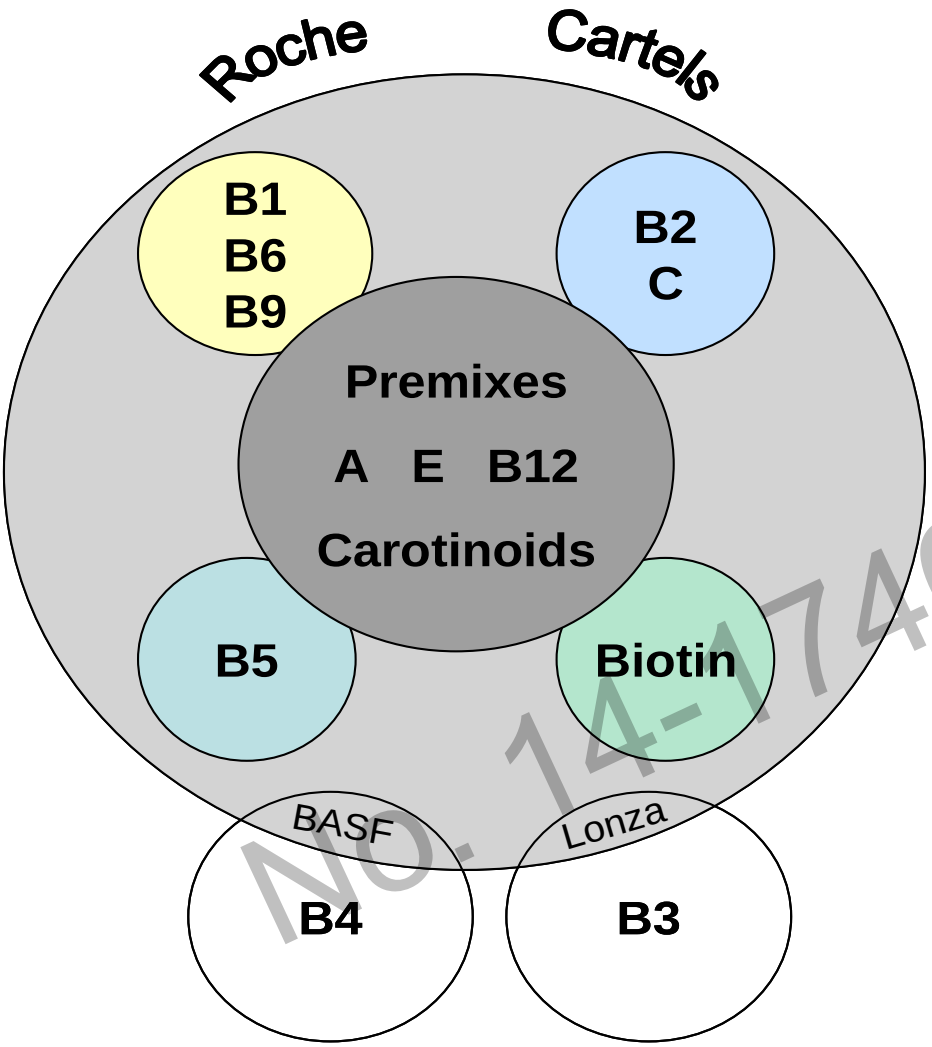
[72] The mix of products that were subject to legal action varies by jurisdiction. The U.S. Government extracted guilty pleas from manufacturers of ten products, but private U.S. plaintiffs received settlements or favorable trial judgments on all 16 products. In Europe, no fines have yet been levied for vitamins B3 and B12 and premixes.

initiating the conspiracy. These may be called the “Roche cartels.” The first two cartels to be formed were at meetings held in 1989 for vitamins A and E. A year later the Big Three European firms and Hoechst formed four more cartels among themselves in the markets for vitamin B12, two carotenoids,[73] and premixes. In early 1990, Roche contacted Eisai of Japan, which was the only significant producer of vitamin E besides Roche and BASF (Figure 3). The last Roche cartel was formed in either 1990 or 1993 when Solvay agreed to join with Roche and BASF to cartelize the vitamin D3 market.[74] Except for D3, these six cartels were all up and running by early 1990 and formed the “core set” of cartels. The six core cartels are symbolized by the dark circle in the center of Figure 2.

[73] Collusion between Roche and BASF in the market for beta carotene began a couple of years earlier than for canthaxanthin and the other carotenoids.

[74] The vitamin D3 cartel was not criminally sanctioned in North America. The EU dates the start of collusion as January 1994, but the private plaintiffs set the date at January 1990. The U.S. transaction prices support the earlier date (Bernheim 2002a:118-119).

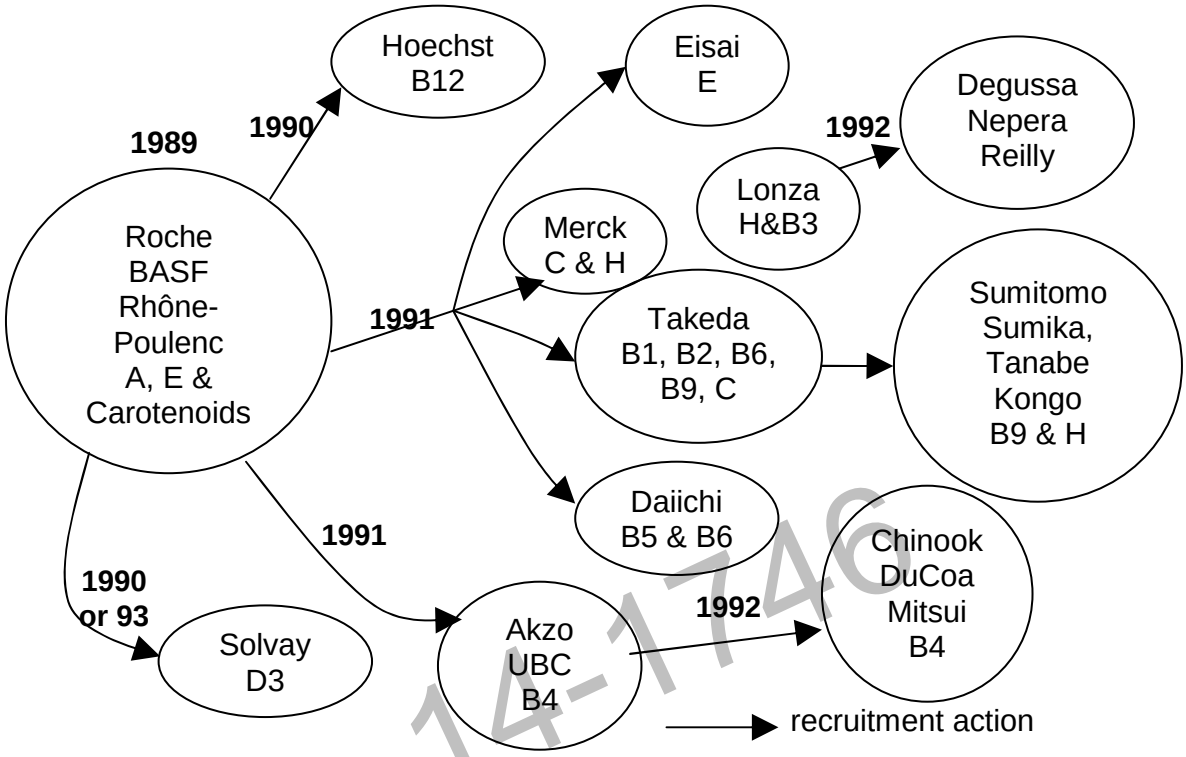
Figure 2. Wheels Within Wheels



16 products, 21 companies

Shortly thereafter in 1990-1991, Roche and BASF reached out to other European and Japanese rivals to consolidate their control of the five core cartels and establish seven more cartels (the four small circles intermeshed with the large grey circle). First, in 1990 Roche contacted Daiichi to form the vitamin B5 cartel, which was underway by early 1991. Second, Roche approached E. Merck and Takeda to complete the membership of the vitamin C cartel and to recruit Takeda for the vitamin B1 and B2 cartels. Third, Takeda agreed to become the go-between in establishing the folic acid (B9) and biotin (H) cartels. In each case Takeda and two of the smaller Japanese manufacturers were needed to surpass the threshold of global control to make price fixing feasible. Therefore by early 1991, all 14 of the Roche cartels were successfully raising the prices of bulk vitamins.

Figure 3. Vitamins in the 1990s: A Web of Conspiracies



Two more cartels got started later. They did not have Roche as a member, but they did have connections with other companies that had joined with one of the Roche cartels. That is why they are visualized as two small white circles just touching the large grey circle in Figure 1. First, the vitamin B3 cartel was launched in early 1992 by the dominant global producer, Lonza, which had begun colluding in the biotin market with Roche and others a year earlier. Lonza seems to have been the ringleader of this cartel that brought in one German producer and two smaller U.S. manufacturers. Second, the choline chloride (vitamin B4) cartel was the most remote from the Roche cartels. It comprised two branches, one centered in North America that had begun in 1988 with a Canadian, a Japanese, and a U.S. company. The other branch was initiated by BASF in 1991; together with two other European choline chloride makers, BASF negotiated an agreement with the three North American manufacturers that divided the two geographic markets through a cessation of trans-Atlantic trade in early 1992. Thus, though briefly joined by negotiations, the result was the establishment of two autonomous cartels, each branch with a geographic hegemony.

Now the conduct of the16 cartels is discussed in greater detail.

The Roche Cartels

Vitamins A & E

Hoffmann-La Roche was the largest seller and took the lead in organizing and managing 14 of the conspiracies. BASF was Roche's willing partner in ten of the collusive schemes. The first and most important largest group was formed by Roche, BASF, and Rhône-Poulenc for vitamins A and E; soon thereafter the Japanese pharmaceutical company Eisai was drawn in to strengthen the vitamin E cartel. These committees began to refer to themselves as "Vitamins Inc.," a fictional joint venture that would conquer nearly all the vitamins markets of the world.

Against a backdrop of falling prices in the late 1980s, the presidents of the vitamins divisions of Roche and BASF met in a hotel in or near Basel, Switzerland on June 7, 1989 to start the new conspiracy in motion (EC 2003, Barboza 1999). Two months later the Roche and BASF presidents invited the head of Rhône-Poulenc Animal Nutrition to join them at a planning meeting in Zurich, Switzerland. The three men conferred again in Zurich for two days in September, 1989. By the end of the four days of meetings, the objectives and general organization of the vitamins cartels had been agreed upon.

The three companies agreed to raise the prices of vitamins A and E in stages beginning in 1990 to what they believed were optimal levels. They also shared data on the size of these markets to arrive at a consensus on 1988 sales volume for each firm and the whole market. They then agreed to freeze their firms' market shares at the 1988 levels for the foreseeable future; growth of the market would be shared proportionally to their quotas. Other rules were adopted regarding sales practices and a compensation scheme to handle year-end deviations from assigned quotas. Late in 1989 a fourth meeting was held in Basel during which country-by-country market shares were set, 1990 sales were forecasted, and sales shares were converted to tonnage quotas for every region of the world. These late summer or fall gatherings came to be known as the "budget meetings."

The planning and management structure created to operate Vitamins, Inc. was in comparison to many contemporaneous international cartels extremely elaborate. Four integrated layers of cartel management were created. The top-level budget meetings were attended by the most senior officers of the companies' vitamins divisions, sometimes accompanied by the chiefs of global vitamins marketing. Budget meetings for the A & E cartels would be held in or near Basel at least once each year in September or October from 1989 to 1999. After initially setting up the cartels, they became a venue for approving specific plans for the following year that had been drawn up by their lieutenants. In addition, the attendees at the top-level meetings made occasional small adjustments to company quotas and adjudicated disputes that lower level managers could not resolve. In some years a second summit was held on a rotating basis among sites in Basel, Paris, and Frankfurt.

At the second level were meetings of the chiefs of global vitamins marketing. They met among themselves two or three times each year to develop specific plans for the following year and to monitor implementation of the annual budgets. One of these meetings occurred at hotels in or near Basel each August. At these meetings, detailed company sales information would be exchanged, and price increases were agreed upon. The price increases were always multiples of 5% and were meant to take effect in April of the following year. For example, in 1989 the decision was made to increase the prices of vitamins A and E in the spring of 1990. They also agreed which of their members would take the lead in announcing the price increase (usually Roche was designated but occasionally BASF was tapped for the role). Then after the anointed "price leader" announced the new list prices, the others would pretend to follow the increase that had been preordained eight months earlier.

At a third layer of cartel management, the heads of worldwide product marketing met four times per annum. It was their function to monitor the progress of the annual quotas and make a progress report to the next layer above. Sales volumes were reported on a monthly basis.

Finally, regional product marketing managers assembled four times per year to monitor regional quotas, to assess trends in demand and supply, and to make small changes in prices in local currencies. For example, the committee handling sales in the European region met in Basel like clockwork in January, April, July, and October each year; "Europe" included sales in Western Europe, Eastern Europe, Africa, and the Middle East. The other regions were North America, Asia, and South America. Spreadsheets were prepared by the regional marketing managers that identified the producers by numbers, not names. A special task at the January meeting was to arrange compensatory sales from over-quota members to those that were under-quota. The sales were made at cost so that when the under-quota members resold the product at the cartel price, the excess profits made by the over-quota firms in the previous year were in effect transferred to the under-quota buyer. In 1996 and 1997 both Roche and BASF had to make compensation purchases (*ibid.* ¶225).

With minor variations, the management structure designed for vitamins A and E would be adopted for all the other Roche cartels.

Market Structure and Entry Deterrence

The vitamin A cartel controlled an average of 96% of global sales during the conspiracy years (Appendix Table 6). The remaining 4% of production was in the hands of Russian, Indian, and Chinese manufacturers (*ibid.* ¶225). As the cartel raised prices from 1990 to 1996, the Russian fringe producer entered in 1991 and captured as much as 10% of world production in 1993-1994; even as prices remained high in 1995-1998, Russian supplies ranged from 5 to 8% of production (Bernheim 2002a: 86). It seems likely that some of the Russian output was exported to Western Europe, where they had some restraining influence on prices of vitamin A. While prices in euros rose each year from 1990 to 1998 (Appendix Table 3), the rate of increase was lower than in the U.S. market. A very small amount of Chinese supply appeared from 1989 to 1995, supplanted by an equally small amount of Indian output in 1996-1998. However, total Asian production never exceeded 2% of global supply in the 1990s. Although very little actual entry took place during the conspiracy period, Roche told the European Commission that the cartels contemplated and explored measures to eliminate or deter these marginal producers from entering Europe.

The stability of vitamin A world market shares among the three cartel members is remarkable, which is evidence that the original 1990 quota allocations probably did not need to be renegotiated. For example, Roche did absorb about half of the cartel's loss of market control in the late 1990s, but *within* the cartels Roche's share never wavered from 48% (Appendix Table 6A). Similarly, BASF adhered to its assigned 28% cartels quota, and Eisai held to 21% throughout 1990-1998. Market shares were allowed to be different at the regional levels; Roche and Rhône-Poulenc, for example, had higher shares in North America than in the world generally (Appendix Table 5).

The vitamin E industry was slightly less concentrated than vitamin A. The three original conspirators accounted for 87% of the vitamin E world market in 1990, the first year of the cartel's operation. However, without Eisai's cooperation, the cartel found that price increases were somewhat sluggish in the first year. After Eisai joined in early 1991 and raised the cartel's market control to 96%, world prices rose by more than 20% per year through 1993, peaking in 1997-1998.

High prices in 1991-1996 boosted modest fringe production; manufacturers in China, Russia, and Slovakia managed to capture 4% or 5% of world production during those years. In the mid and late 1980s, none of these fringe firms had had commercial sales. Up to 1996, imports into the largest markets, Western Europe and North America, were insignificant. However, there is some indication that Chinese producers may have begun challenging the cartel in its last two years. Chinese output doubled from 1996 to 1997 and reached 11% of global output in 1998; indeed, Chinese production surpassed that of Eisai, the smallest cartel member, in that year. The lion's share of Chinese production, most of it feed grade, was exported. By 1998 Chinese imports captured about 7% of the European market, but euro prices remained steady 1997-1998. Vitamin E prices did not decline until 1999, the year the cartel was discovered by the U.S. DOJ. However, Chinese imports may have had a stronger effect in the U.S. market. There the prices of feed grade vitamin E fell about 10% from 1997 to 1998, and human grades of vitamin E by about 5%.

As in the vitamin A case, there is no evidence of dissention among the four members of the vitamin E cartel. The ringleader Roche maintained a steady 46 to 48% share of the cartel's production from 1990 to 1998 (Appendix Table 6A). The other three members' intracartel shares were similarly invariant over the nine years of collusion.

Pricing Policies

The general principle enunciated repeatedly by the managers of the vitamins cartels was "Price before volume." What this seems to mean is that the conspirators would give precedence to increasing price at a higher rate than the rate of losses of tonnage due to the price increases.[75] That is, the aim was to increase market price so long as total revenues or profits increased.

The organizers of the cartel prepared planning documents with two prices, one a "target price"[76] and a second "lowest price." Initially, prices for vitamins A and E were set in U. S. dollars (USD) and in Deutsche marks (DEM).[77] A price list distributed to Roche's product managers in March lists target and lowest prices in both dollars and marks (EC 2003: ¶207). The document reveals that Roche's corporate objective was to raise prices of the two products by 5 to 10% when measured in Swiss francs (CHF). At the same time, an objective was to keep the USD and DEM prices close enough that vitamin brokers could not profit from geographic arbitrage.[78] Sales managers were instructed not to sell at any price that would cause Roche's market share to rise above 48%.

[75] "Price over tonnage" must mean more than the fact that they are inversely related. In economic terms Roche was encouraging the cartels to raise price toward the inelastic portion of the demand curve. When demand is inelastic a small percentage increase in results in a smaller percentage decrease in quantity sold. Monopolists and effective cartels will maximize profits when their equilibrium reaches the inelastic zone of demand.

[76] Roche and BASF documents obtained by the European Commission use the German word *Ziel* (EC 2003: ¶205), which can also be translated as aim, goal, intention, or objective.

[77] The full published version of the EC vitamins cartel decision (EC 2003) reports the prices of many products in Swiss francs, but translates most of the 1989-1992 monetary figures from DEMs into euros. Officially the euro did not exist until 1999. However, one can use the ecu (the European Currency Unit or ECU), the forerunner of the euro, to convert DEMs into euros. The euro replaced the ecu at par in January 1999 and became legal tender in most of the EU on January 1, 2002. For the years prior to 1999, the ecu will be referred to as the euro.

[78] If currency swings between the USD and DEM caused to price of a vitamin to rise by more than 5 or 10% in Germany, then U.S. wholesalers could purchase the vitamin in the United States at a low price (when denominated in DEMs), pay for transportation to Germany, and reap a risk-free profit when sold at

The cartel managers were not averse to reaping windfall profits when the opportunity presented itself. In early 1991, Rhône-Poulenc's vitamin E plant experienced a fire that interrupted production (EC 2003: ¶213). The temporary reduction in supply was a perfect public excuse to raise prices even more than originally planned. Instead of a 5 to 10% increase in Swiss prices, the cartel quickly decided to aim for a 15% increase in early 1991. Because the Swiss franc appreciated relative to the DEM, in the rest of Europe vitamin A and E prices rose by 24% in 1991.

Cartel managers were ever watchful to the dangers presented by arbitrageurs. In early 1994, Roche sent a memorandum dated 4 February 1994 to its regional sales managers that said that because of currency exchange swings the price gap between Europe and the United States for vitamins A and E had grown to about 10% (EC 2003: ¶223).[79] The memo warns that brokers were using this gap to engage in arbitrage. To counter this behavior, the memo states that the

> "… key focus regarding 1994 is therefore on Europe…Our objective is to bring A prices up by DEM 2 and E prices by 1. Volumes need to be strictly controlled" (*ibid*.).[80]

The pricing goals of the vitamin A and E cartels were ambitious and successful. From 1990 to 1994, the European price of vitamin A rose by 29%; vitamin E increased by 56% (EC 2003: ¶221). Similar price increases occurred in the rest of the world. The signal success of these cartels was so great that in 1994 Vitamins, Inc. decided to hold prices steady from 1995 on.

Cartel Expansion

The period from January 1990 to January 1991 was especially busy for the three founding members of Vitamins, Inc. In early 1990, the increases in vitamin E prices had been limited to a somewhat disappointing 5 to 10% worldwide (EC 2003: ¶ 213-215). The cartel managers ascribed this weak price response to an increase in sales by the Japanese pharmaceutical manufacturer Eisai. When the vitamin E cartel began, Eisai had a global share of slightly less than 10%. Thus, in September 1990, the vitamin-division presidents of Roche, BASF, and Rhône-Poulenc journeyed to Japan to woo Eisai into the fold. On October 30, 1990 top executives of Eisai traveled to Basel to finalize a membership agreement. Meeting only bilaterally[81] with the three ringleaders, Eisai agreed to accept a 1600-tonne world quota for 1991 in return for a promise that its share would rise to 11% and remain at 11% for the duration of the cartel. After January 1991, Eisai maintained bilateral contacts only with Roche representatives, so Roche became the primary coordinator of the vitamin E cartel.

Fear of Prosecution

Managers of the vitamin A and E cartels took steps throughout the conspiracy to hide their activities. Meetings were held at hotels and other places away from their offices and

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the higher price in Germany (see Bush *et al.* 2004). If the dollar rose against the mark, reverse arbitrage could occur.

[79] The average exchange rate in February 1994 was 1.7675 DEM/USD, up from 1.6777 in September 1993, an increase in the exchange value of the U.S. dollar of 5.4%.

[80] In 1994, vitamin A was selling in Europe for DEM97 per kilo and vitamin E for DEM57. Thus the price increases were modest, only 1.8 to 2.1% (EC 2003: Tables II and III).

[81] Eisai and some other Japanese conspirators seem to have got the idea that bilateral meetings could not violate the antitrust laws.

curious business colleagues. Eisai engaged in only bilateral contacts with its cartel partners, perhaps to maintain the deniability of cartel meetings. Conspirators in Europe were careful not to leave incriminating documents at their business locations where a dawn raid might lead to their discovery.[82]

In January 1993, the *Conseil de Concurrence* (the French competition-law authority) received complaints from buyers that vitamin manufacturers were raising prices to unjustified levels in concert. The council responded by raiding the headquarters of Rhône-Poulenc Animal Nutrition in Paris. Roche informed Takeda Chemical about the raid, and Takeda kept this record of the message:

> "Nothing was found in the investigation…nothing was found…[Roche] does not consider these inspections problematic: however they are being careful as to how they handle documentation" (ibid. ¶223).

Things took a more serious turn in the United States in 1997. The U.S. DOJ had been busy prosecuting the lysine and citric acid cases throughout 1996 and early 1997. In early 1997 the FBI received information about a possible price fixing conspiracy in the vitamins industry. In March of that year, FBI agents interviewed Dr. Kuno Sommer about the matter. Sommer was the global head of vitamins marketing for Hoffmann-La Roche and also served on Roche's small management committee that formed the pinnacle of the company's management structure. If anyone should have known about vitamins price fixing within Roche, it was Sommer. Sommer's interview would have serious legal consequences for him and Roche if he did not answer truthfully. First, it is a federal crime to lie to federal investigators; second, he was interviewed under the January 1997 citric acid plea agreement in which Roche had promised full cooperation from its employees in any antitrust investigations.

Sommer denied that Roche was involved in any such illegal activity. Later it came to light that Sommer had prearranged with others at Roche to cover up the vitamin cartels' existence. Because Roche was the only vitamin co-conspirator with a cooperation pledge, Sommer's denials impeded FBI's investigation considerably. However, in late 1997, the DOJ investigation picked up speed again. A civil price-fixing case was filed by bulk vitamins buyers, and this action prompted the U.S. Department of Justice to empanel a grand jury in Dallas, Texas to investigate allegations in December 1997. Word leaked out about the grand jury. Press reports revealed that numerous executives responsible for procuring vitamins for animal-feeds manufacturers were being interviewed about possible price fixing activities in the industry. This grand jury would toil away in secret for 16 months before the first fruits of the investigation would become public. By mid-summer 1998 strong and persistent rumors had begun circulating among Washington antitrust lawyers that indictments were likely in the case of vitamins A, C, E, and riboflavin; Roche and BASF were mentioned as targets of the vitamin probe.[49]

In response the cartels reduced the frequency of their meetings. The last tripartite meeting of the vitamins A and E cartel took place in Basel in November 1997. Thereafter, the conspirators would meet only bilaterally. Moreover, top-level meetings became "more discrete" (ibid. ¶231). Meetings began to take place in executives' homes so that there would be no lodging records to be later discovered. On December 22, 1997 Rhône-Poulenc announced to the other members of the cartels that it had decided to quit the conspiracy. This announcement was a sham as the company continued to meet with Roche and BASF in 1998.

[82] Prior to 2004, EC regulations permitted only places of business to be searched. Executives' cars and homes were off limits.

Duration

Collusion in the vitamin A and E markets did not end until February 1999, a total run of 117 months. Because of the large size of the vitamin A and E markets and the longevity of the cartels, the economic harm caused by these two conspiracies would amount to 36% of the economic injuries caused by all 16 cartels.

Vitamin B12 and the Carotinoids

The vitamin A and E cartels made such promising starts in 1990, that Roche, BASF, and Rhône-Poulenc spread their net wider still. The third market monopolized was the global market for vitamin B12. This cartel was one of the few that was not subject to collusion in the 1980s. One reason that Rhone-Poulenc and Hoechst were unable to collude overtly earlier was their low degree of global control of production 67 to 71%). Moreover, they faced two presumably competent rivals in Western Europe, Glaxo in the UK and E. Merck in Germany, that accounted for as much as 22% of industry output; moreover, unidentified Asian producers[83] made as much as 12% of global supply in the late 1990s. Whatever the reasons, Merck shut down production in early 1989 and Glaxo[84] in late 1991, leaving Hoechst and Rhone-Poulenc as the nearly sole producers of vitamin B12 in Europe.[85] Surprisingly, even as prices surged in the early and mid 1990s, Asian production shrank to 10% or less of world production. Chinese entry began on a small scale in 1995 but grew to 9% of world production in 1998. The late entry suggests that the Chinese and other Asian firms were at a cost disadvantage in making vitamin B12 until near the end of the cartel.[86]

The vitamin B12 cartels began in January 1990, suggesting that planning had occurred in late 1989 simultaneously with the vitamin A and E cartels. In terms of timing, the B12 cartel was virtually coterminous with the A and E cartels, except that it ended about a year earlier. The two firms accounted for only 69% of global supply in 1990, Rhône-Poulenc (62%) and its much smaller German partner, Hoechst (7%). Unlike most cartels, the degree of supply control rose as prices climbed in the mid 1990s, a pattern that further supports a cost advantage by the duopoly. At the cartel's peak the two firms controlled 81 to 86% of world production -- about 95% of the European market but closer to 85% of the North American market (Appendix Tables 5 and 6).[87] The vitamin B12 cartel was in effect a merger ten years in advance of the late 1999 formal merger of the two companies into the firm now called Aventis.[88]

Far larger in scope were the two cartels for carotinoids, the older product beta carotene and three other carotenoids. Like vitamin B12, they were duopolies that endured from early 1991 to December 1997. Roche and BASF are the only known producers of synthetic carotinoids in the world. No entry occurred into these industries, even though they are among

[83] They were not from China, India or Japan.
[84] Glaxo held an 8% share in 1991 and Rhone's increased by 5 percentage points the next year; it is possible that Rhone acquired Glaxo's plant.
[85] A Hungarian company held 6 or 7% of the global industry throughout most of the collusive period.
[86] Small-scale Indian manufacturing began in 1998.
[87] This pattern suggests that there may have been
[88] Aventis was formed in December 1999, and its headquarters moved to the French province of Alsace about midway between the two companies' former headquarters. As of 2005 neither Aventis nor its predecessor companies have been charged by the United States or the EU in the B12 market. They *were* found guilty by Canada. There is a strong possibility that in 1998 the liabilities created by participation in the vitamins cartel were seen as the only impediment to the impending Aventis merger. Although the U.S. and EU amnesty programs are given most of the credit, the major vitamins cartels may have been exposed by Rhône-Poulenc as part of a secret deal to obtain merger approval in Europe and the United States.

the fastest growing vitamin products.[89] As the most recently synthesized vitamin products, technological barriers to entry are substantial.[90]

The first contacts about forming a cartel for carotinoids began in 1991 (EC 2003: ¶520-534). Formal negotiations began in Basel in September 1992 and concerned beta carotene, the orange colorant and the most mature market of the four carotinoids. BASF was a relatively new producer of beta carotene and had been gaining market share prior to 1991. The 1991 quota agreement began with allotting a global share of 79% to Roche. BASF's 21% share was allowed to increase by about 1 percentage point per year until it would reach 30% in the year 2001. Unlike most of the other vitamins cartels, no regional quotas were assigned. After the initial 1992 meeting, quarterly meetings were held simultaneously with those of the vitamin A and E meetings. Both firms seemed confident that the likelihood of entry by outsiders into carotinoids in the 1990s was remote.

Canthaxanthin, the red carotenoid, was the subject of delicate negotiations between Roche and BASF beginning in May 1993. According to the European commission (2003) by 1993, BASF had reached a 33% share in canthaxanthin.[91] However, BASF also had plans to enter the astaxanthin market in 1996 when a new plant it was constructing was expected to begin production. As an incentive to Roche not to oppose BASF's entry into astaxanthin, BASF agreed to cut its 1994 production share to 29% with the understanding that its share would grow to 35 to 40% by 2002. In return, Roche agreed to let BASF enter the astaxanthin market unimpeded in 1996 and allow its share to grow to 20% by 2002.

The manufacturing processes for the newer carotinoids must be among the most technically challenging of all the vitamins. BASF, a chemical powerhouse with great depth in R&D capacity, faltered badly in its plan to make astaxanthin. Production did not begin until 1999. Thus, the attempt to collude on the pink carotinoids was never implemented. Roche maintained its monopoly on both pink and gold carotinoids until at least 1999.

The two carotenoids cartels came as close to a blockaded monopoly as any of the cartels. Conduct was calm, orderly, and highly controlled. U.S. carotenoid prices were by far the highest of any vitamin product except biotin – human grades of beta carotene reached nearly $1000 per pound and feed grades of canthaxanthin &1500 per pound. Moreover, prices rose inexorably both before, during, and after formal collusion in the 1990s. Roche diplomatically ceded a percentage point or two of market share to BASF each year in order to contain what might have been a more aggressive rate of entry by the smaller partner in the cartels.

Feed Premixes

There is little reliable information about the structure of the industry that sells mixtures of bulk vitamins to large agricultural producers, feed manufacturers, and pharmaceutical manufacturers of multi-vitamin supplements. In general, there seems to be a large number of small premix companies that typically operate a single plant to serve sub national markets. Two larger independent blenders in the United States are ADM and Nutra-Blend. However, two companies stand out in this generally atomistic industry. Hoffmann-La Roche and BASF had leveraged their broad vitamin product lines and knowledge of animal nutrition into chains of

[89] Carotinoids are relatively fast growing products because they are replicate the red, orange, and gold pigments found naturally in fruits, vegetables, and the flesh of fish. Humans find these hues appetizing in their foods. Carotinoids have the further advantage of evolving into vitamin A after ingestion. Demand growth for beta carotene in the late 1980s and early 1990s averaged 10 to 12% annually.

[90] Sumitomo manufactured tiny amounts of beta carotene in the 1980s

[91] This appears to refer to Europe, because on a global basis BASF had canthaxanthin shares of 20% in 1993 that grew to 32% in 1998 (Bernheim 2002a: 115).

premix plants that could serve the whole of North America or the European Union.[92] By 1990 they had expanded their premix operations to occupy leading positions in those markets, though the size of those shares is difficult to determine. Roughly speaking the two firms seem to control about half of the North American and European markets for feed premixes, with Roche about twice the size of BASF.

As a long term business strategy, the formation of the premix cartel may have been provoked by the steady loss of the two companies' market shares and the evolution of bulk vitamins into standardized commodities.[93] The premix business still had the possibility of future consolidation and a degree of service differentiation that held out the promise of higher profits. One of their aims in forming the bulk vitamins cartels was to further the development of dominant positions in the downstream premix business.

Vitamins B1, B2, B5, B6, B9, C, and Biotin

Seven of the water-soluble vitamins were cartelized in late 1990 or early 1991; five are in the in the B complex; vitamin C and biotin (vitamin H) are also water-soluble. The proximate cause of the formation of these six cartels was falling profits. According to the European Commission, one participant asserted that the prices of all the B complex vitamins had been falling during the 1980s. Transactions price data in the United States do not support this sweeping claim. Vitamins B1, B2, B5, and B6 had falling nominal prices in the early 1980s, but by 1988 or 1989 prices had recovered to their previous peaks. Only in the cases of biotin and folic acid did prices fail to recover to their previous heights by 1988 or 1989. However, it is true that modest declines in prices did occur in the year or two prior to the re-establishment of the six cartels.

One factor responsible for the decline in prices in the early 1980s was the growth in Japanese exports of B complex vitamins to Western Europe and North America. Roche experienced a large loss of market share from the mid 1970s to 1990, with most of the gain going to Japanese producers.[94] Roche also saw its global shares in the B complex vitamins shrivel during the first episodes of price fixing in the late 1980s.[95] Another factor contributing to the slide in prices in 1989 and 1990 was the weakness of the U.S. dollar relative to the yen, the Swiss franc, and most other European currencies. In most parts of the world outside Europe vitamins were sold in dollars, which adversely affected profits of companies whose accounts were kept in currencies other than the U.S. dollar.

To be successful in establishing cartels for the B vitamins, the three founding firms had to reach out beyond the circle of five firms already successfully colluding on four products (Figure 2). Each of the new cartels would require only three or four members to control the markets. Generally speaking, the makers of vitamins B1, B2, B6, folic acid, and C met together, but the complexity of the task required two days of work each time.

[92] Rhone-Poulenc entered in 1998.
[93] Roche controlled 65% of the European market in the mid 1970s but was down to 50% by 1990.
[94] According to one source, Roche lost 32% of its European share of vitamin B1, 44% of B2, 31% of B5, 43% of B6, 7% of B9, and 61% if biotin during these 15 years (Appendix Table 5). Takeda, Daiichi, Kongo, Sumika, Sumitomo, and Tanabe were companies that captured market share during this period. Within Europe, BASF, Lonza, and E. Merck gained market share.
[95] In many cases Roche's global shares of production had recovered somewhat in the early 1980s, but they slipped 11% in the vitamin B1 industry from 1985 to 1990, 21% in B2, 7% in B6, and 41% in biotin (Bernheim 2002a: 96-120). Its share was steady in vitamin B5 and folic acid.

Vitamin B1

The vitamin B1 (thiamin) cartel began at a January 30, 1991 meeting in Tokyo between Roche and Takeda; several other Japanese vitamins manufacturers were present (EC 2003: ¶244-269).[96] Internal Takeda documents showed that Roche and Takeda shared their 1990 production and sales of vitamin B1 for the world and four regions, and agreed to use the 1990 historical shares as the basis for setting 1991, 1992, and 1993 quotas. In fact, Roche and Takeda honored their agreement faithfully until the cartel collapsed in mid 1994. From 1991 to 1993 Roche maintained a 56 to 57% of cartel production

Prices in the EU had dropped about 5% from 1988 to 1989, despite the withdrawal from production of the third largest manufacturer in 1989. An unusual feature of the vitamin B1 industry was the fact that BASF had decided to cease manufacturing vitamin B1 in 1989, but remained a seller of bulk vitamin B1 through a long term (1989-1994) supply contract with Roche. In 1990 Roche manufactured 50.8% of the world's supply, and Takeda made 36.2%.[97] However, almost one-fourth of Roche's output was committed to BASF under the supply contract, presumably at favorable terms.[98] At the Tokyo meeting, BASF was awarded a market share that kept its sales in a constant ratio with Roche's share. Although BASF never met with Takeda about its role in the cartel, it was kept informed about the prices and share quotas that were set by the other two.

Another feature of the vitamin B1 market was the significant and rapidly growing share of Chinese producers. In 1989, Chinese sales had reached about 9% of global supply (another 3% was made elsewhere). By 1991, China's share would grow to 20%. At their Tokyo meeting Roche and Takeda estimated that the Chinese share would grow to about 25% by 1993. In fact their expectations would prove to be optimistic, because in 1993 Chinese output would actually reach 38% of world production.

The rapidly growing Chinese exports were flowing mainly to Asia and North America; Chinese imports into Western Europe remained in the 9% to 12% range in the early 1990s, a level that is worrisome but not necessarily destructive of cartel effectiveness. During the 1991-1994 cartel period in North America cartel controlled dropped to less than 60%, which is a level at which it is difficult to maintain collusion.

Another feature of Chinese exports is that initially they were viewed by buyers in the major industrialized countries as inferior in quality. That is, Chinese product was a closer substitute for feed grade vitamins than for human consumption. This is demonstrated in the U.S. vitamin B1 market by the differential response of prices to the surge in Chinese imports from mid 1998 to the end of 1989. U.S. prices of *feed-grade* vitamin B1 tumbled by about 15%, whereas the price of *food-grade* product declined by less than 5% (Bernheim 2002a:109). During the 1990s Chinese manufacturers would invest in high-tech equipment that would permit the sale of vitamins with higher levels of purity compatible with pharmacopeia standards.

In 1990, Roche and Takeda viewed Chinese vitamin B1 as suitable only for a minimally acceptable feed grade (EC 2003). Yet, Takeda's experience was that once an account was lost to a Chinese supplier, the clients did not return. To respond to the Chinese challenge, Takeda considered offering a "sub-spec" feed-grade product of its own and compete on price. In June 1993, by which time the challenge had turned into a crisis, Takeda instead decided to introduce

[96] After the initial meeting, Roche and Takeda met quarterly at meetings that combined top-level executives and operational managers. The meetings often lasted two days because the two companies had five products in common: vitamins B1, B2, B6, C, and folic acid. Sometimes BASF would be present for the sessions dealing with vitamins B2 and C, and E. Merck would join the vitamin C sessions.
[97] These are EC estimates, but those of Bernheim (2002a: 108) are very close.
[98] The fact that Roche could increase its production by 30% from 1988 to 1989 indicates that it had substantial excess capacity.

a discriminatory pricing policy. To woo lost customers back Takeda would match the Chinese on price on feed-grade product while at the same time charging loyal customers a higher price. Roche seems to have adopted the same desperate and ultimately ineffective strategy.

Chinese exports were shipped by several nominally independent firms, but many of them were government owned and belonged to a trade association that provided a degree of centralization of decision making. At no time does the record show that any of the vitamins cartels attempted to recruit or co-opt members of the Chinese chemical industry. Instead they were viewed as mavericks hell-bent on maximizing their share of the world market through fierce price-cutting.

The rise of Chinese exports played a key role in several of the vitamins cartels. Chinese exports were increasing before most of the B complex cartels were formed in 1990-1991, but their greatest rate of growth began from 1991 to 1995. In those four years, the real value of Chinese vitamin exports rose by 250% and the quantity tripled. Doubtless, the increase in the prices of the vitamin C and the B complex vitamins was a major factor that encouraged that explosive growth.

After the cartel was formed, vitamin B1 prices in Europe did rise 5 to 6% in the first two years (Appendix Table 4). However, by late 1992 Chinese imports into the EU had reached 18% of supply, and those imports had begun to restrain EU price increases. In the U.S. market for vitamin B1 prices rose 15% from January 1991 to late 1992. Vitamin B1 prices peaked in early 1993, but fell rapidly thereafter. EU feed-grade prices fell by 26% from mid 1993 to the second half of 1994. U.S. prices tumbled 20 to 30% during the same period. At a meeting in June 10, 1994 Roche and Takeda abandoned price fixing. By 1996-1999, the prices of both grades of vitamin B1 had declined by more than 50% from the 1993 peak.

At three and one-half years, the vitamin B1 cartel was the second-most fragile of all the vitamins schemes (Figure 3). Although it died the kind of natural death that true believers in perfect competition expect to be the norm, it did in fact turn out to be a profitable venture while it lasted. Whether the cartel could have made more money through a strategy of slowly *lowering* prices and thereby extending the collusive period is doubtful.[99]

Vitamin B2

The history of this cartel parallels that of the vitamin B1 cartel in several respects. Roche, BASF and Takeda were the three dominant sellers in 1990, with 87% of the world market under their control (Appendix Table 6). Takeda, which had entered the industry only in 1990, was the smallest member of the cartel established in 1991. In addition, the fringe producers in the vitamin B2 industry differed from that of B1. Eastern European producers accounted for about 10% of the European market for vitamin B2, the Japanese manufacturer Tanabe was the main outsider in Asia, and the U.S. company Coors supplied a similar share of the North American market in 1990-1994. Chinese entry was no long-term threat to the cartel: production lasted for only two years (1992-1993).

From 1988 to 1990 the EU price of vitamin B2 fell by 12% (EC 2003: ¶270-291). In the United States, the price of feed-grade vitamin B2 fell about 15% at the same time, but human grade was unchanged. In response to falling prices and the evident success of the vitamin A and E cartels, Roche and BASF executives met in Bottmingen, Switzerland in July 14-15, 1991

[99] This pricing strategy is called dynamic limit pricing in the economics literature (Gaskins 1971?). Recall that before the cartel was created, it was effectively a global duopoly with a minimal competitive fringe. Prices in the EU were quite high in the years prior to the cartel's formation (€27 to €28 per kilo, or 42 to 48% above the post-cartel prices), probably because of tacit collusion between Roche and Takeda (EC 2001: Table IV).

to discuss a vitamin B2 cartel.[100] The two companies accounted for 84% of global supply. At the Swiss meeting they agreed to raise prices and to fix volume quotas for the top three sellers for the years 1992 to 1996 at levels equal to actual 1990 levels. Roche and BASF also agreed to set up the four-tier system of cartel management with quarterly meetings that was being used in the vitamins A and E cartels.

Soon thereafter senior Roche and BASF representatives separately traveled to Japan to convey the cartel's market-share proposal to Takeda (*ibid.*). Unlike vitamin B1, Takeda was in a relatively weak third place in the industry, with only 3% of global output. So by late 1991 or early 1992 it accepted the Roche-BASF offer of a 12% global share.[101] Roche and BASF both gave up considerable market shares in 1992 to allow Takeda's share to rise. Roche and Takeda met in Basel on April 13, 1992 to finalize some details on the cartel's policy of continuous increases in prices. Subsequently, Takeda met quarterly with Roche and BASF, but always bilaterally. The three conspirators exchanged sales data on a regular basis for five global regions: Europe,[102] North America, Latin America, Japan, and the rest of Asia.

Takeda officials kept detailed minutes of their many meetings with Roche and BASF officers, even though some of them were headed by a warning: "Destroy after reading." These notes contain items that indicate constant bickering about shading of prices by Takeda, sales to specific customers, and concerns about market shares of various grades of Vitamin B2. Takeda found its initial agreement to accept a constant 12% global share hard to live with. Takeda claimed that the rising prices of vitamin B2 kept its volume of sales virtually constant from 1990 to 1992.[103] In late 1992, Takeda demanded an increase in its 1993 volume of sales to 500 tonnes, about 30% more than it had previously agreed. Roche representatives angrily rejected the demand, but Takeda's stubborn insistence on a larger volume of sales eventually had its intended effect. In the interests of cartel harmony, Roche and BASF agreed to yield some of their shares to Takeda, which gave it a 15% increase in volume. Takeda's global share would grow from 13% in 1992 to about 17% in 1994, almost all at the expense of Roche.

The vitamin B2 conspiracy is an interesting illustration of one in which constant annual renegotiations were needed to maintain pricing discipline. In 1991 when the cartel was initiated by Roche and BASF alone, they agreed to a 64:36 split (Appendix Table 6A). To entice Takeda to cooperate Roche gave up 9.7 percentage points of intra-cartel share and BASF a proportional 5.0 points as a reward to Takeda for joining. Then to satisfy Tanabe's further demands, the two leaders ceded another 4 percentage points of the cartel's total production to Tanabe from 1992 to 1994. Finally, the two leaders needed to accommodate a fourth member. Rhone-Poulenc began selling vitamin B2 in 1994; by the next year it had been generously granted a 10% share of cartel production, which was carved out of the two leaders' quotas.[104]

[100] There is no specific evidence, but it appears likely that initial discussions about a vitamin B1 cartel may have taken place in Tokyo in January 1991 when Roche senior executives visited Takeda. It is possible that Takeda wanted to delay talks about a cartel because it was expanding its vitamin B1 plant in Japan at the time.

[101] Tanabe had a 7% global share in 1990 but dropped out of the market at the end of 1990 or beginning of 1991. Tanabe would join the biotin cartel, but it may not have been appraised of the vitamin B2 agreement. Even with substantial excess capacity, it is highly unlikely that Takeda could have quadrupled production from 1991 to 1992. Therefore, it seems that Tanabe must have sold or leased its Japanese production capacity to Takeda by early 1992. This is consistent with many other acts of deference shown by the smaller Japanese vitamin makers to Takeda in the 1990s. Tanabe was dependent on supplies of vitamin B1 from Takeda.

[102] As usual, "Europe" is a designation that includes Africa and west Asia.

[103] The only way this can be close to true is if Takeda is lumping Tanabe's 1990 capacity with its own.

[104] Beginning sometime in late 1995, Rhone-Poulenc began to sell product made by ADM in its U.S. plant. The record is unclear about whether Rhone-Poulenc actively colluded with the other three. The

After less than five years of collusion, Roche had gone from a 64% intra-cartel quota to a mere 45%

Despite the evidence of continuing disagreements over market shares, the minutes also show a continuing commitment to the overarching principle of "Price before quantity." That is, prices were continuously, even experimentally raised despite the fact that quantity growth was being adversely affected. Like the earlier cartels, the vitamin B1 conspirators agreed to two sets of prices: list (or target) and lowest. The minimum prices were about 5% below the target prices. Moreover, feed-grade prices were kept in a nearly constant ratio to the human grade – feed grade was priced about 80 to 83% lower than human. Following these customary discounts made the process of arriving at a consensus on prices quite manageable. In effect, the cartel needed only to agree on a target price for human-grade vitamin B1; deriving all the other prices was a mere arithmetic exercise.

While the vitamin B1 cartel negotiated a solution to an internal threat to its stability, it was less successful in dealing with an external threat. The external threat did not come from China this time, but rather from the United States. In 1991 and 1992 the three members of the cartel believed that only two significant rivals remained outside the cartel: Coors in the United States and the GUS group in Russia. They were believed to hold about 4.6 to 4.8% of the global market in 1990 and 1991 – a share small enough to be safely ignored for collusion purposes. However, in 1993 the cartel discovered that the U.S. brewing company Coors had built a vitamin B2 biotech plant with 230 tonnes capacity, about twice as large as they had estimated in 1991. To protect prices outside the United States, Roche contracted to purchase half of Coor's capacity, an amount sufficient to prevent Coors from exporting vitamin B2. Roche then sold a portion of its purchase to BASF in an amount that preserved their relative quotas. This was a cunning, if expensive solution to foiling large-scale entry into the cartel's market.

The vitamin B2 cartel unraveled in 1995 because of two events. First, Takeda was caught cheating on its volume agreement. At a meeting with Roche and BASF on March 16, 1995 the Roche representative confronted Takeda with evidence of its perfidy. Roche had discovered from Japanese government trade statistics that Takeda's sales in Japan and its exports amounted to an annual sales volume of 580 tonnes, which was 40 to 50% above its agreed quota.[105] At that meeting, the Takeda representative made an obscure reply to Roche's accusation that was tantamount to admission; later, Takeda told Roche that it was operating at close to its production capacity, but that it would not reduce its sales volume. This episode shows the importance of information-sharing. Overt collusion works best when transparency is complete among cartel participants, and third parties do not have access to facts that cause surprise.

Second, in 1995 the Coors vitamin B2 plant was sold the large agribusiness firm Archer Daniels Midland (ADM). Furthermore, ADM signed a marketing agreement with Rhône-Poulenc

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European Commission does not include the company in its list of violators, but plaintiffs in the United States do. Rhone's passive

[105] Roche was able to estimate Takeda's domestic sales (circa 80 tonnes) by identifying the size of chemical intermediates needed to manufacture vitamin B1; exports of finished vitamin B1 were 500 tonnes. This episode points to a general lesson about the importance of accurate official trade statistics. Even if exports are made by a domestic monopoly or imports are from an overseas monopoly, trade data continue to be published by most governments, contrary to their usual practice of suppressing information about one or a few companies in the name of preserving confidentiality. On the one hand, trade data become at times the sole source of information about quantities and prices of cartelized goods. On the other hand, these same data can assist cartels by providing third-party evidence of cheating; knowing of the likelihood of discovery, many cartel members contemplating cheating will be discouraged from doing so.

to sell part of its U.S. production in Europe.[106] Up until early 1995, ADM had been cooperating with BASF and other companies for more than three years in a successful global cartel in the market for citric acid; this cartel broke up at about the same time as the Coors purchase.[107] As was its usual strategy, ADM decided to expand its vitamin B2 production rapidly. By offering vitamin B2 at a lower price, ADM quickly garnered a 9% share of the European market by the end of 1995, up from 2% at the beginning of the year (*ibid.*). Moreover, ADM's global share almost doubled from 1995 to 1998.[108] Roche's global market share plunged from 56% in 1990 to 41% in 1996.

Prices of vitamin B2 declined in the U.S. market, slowly in 1996 and then rapidly for four years thereafter. Feed-grade prices fell from $62 per kilogram in 1995 to $26 at the end of 2000 – an astonishing 58% plunge.[109] Prices of both types in Europe reached their peak in 1995 at €60.6 ($76) per kilogram and fell to €37.6 in 2000, less than in the United States but still an impressive 38%.

In the fall of 1995, Roche unilaterally informed the others that it would terminate the already sick vitamin B1 cartel.

Folic Acid (Vitamin B9)

Collusion in the market for folic acid, the smallest of the bulk vitamins markets, began as early as the January 30, 1991 meeting in Tokyo between senior officers of Roche and Takeda (EC 2003: ¶354-387).[110] Both sides had come prepared to exchange confidential sales data and were primed to deal.

The folic acid industry consisted of four major players, Roche, Takeda, Kongo, and Sumika/Sumitomo.[111] In 1990 these four manufacturers controlled 96% of world production. Roche asked Takeda, the largest of the three chemical firms, to coordinate cartel decisions with the two smaller Japanese manufacturers. The structure and organization of the cartel was copied closely from the vitamin A and E cartels: multi-tiered quarterly meetings, market shares frozen at 1990 levels, a compensation mechanism to reward under-quota members, and target prices with minimum prices 5% lower set each autumn for the following year.[112] Prices and market shares were set for four regions: the USA, Europe, Japan, and the rest of the world.[113] The Japanese members of the cartel met quarterly simultaneously with the Yosankai trade association originally established by Japan's Ministry of International Trade and Industry.

Information provided by Takeda indicates that Roche had dual objectives in forming the cartel. Roche desired to profit from the sale of straight folic acid but also wanted to raise the prices of bulk folic acid in order to improve its market position in the downstream market for feed premixes. Roche would benefit because the various vitamins cartels would raise the cost of the premixers' principal input, bulk vitamins. Because Roche could supply its own growing premix

[106] ADM and Rhône-Poulenc had history of cooperation; they owned a joint venture in a methionine plant in West Virginia.
[107] ADM was raided by the FBI for suspected cartel activity (lysine, citric acid, and high fructose corn syrup) in June 1995. Perhaps this event spurred ADM to increase its share in vitamin B2.
[108] Bernheim (2002a: 102) is inconsistent in its treatment of Rhone-Poulenc's sales, which it labels production. In 1995, ADM seems to have made 13% of the world's vitamin B2 in 1995 and 23% in 1998. This is a huge increase from 1992 when Coors accounted for only 5%.
[109] Human grade fell from $73 to $43 during the same period, a 41% decline.
[110] Folic acid was one of the few markets not preceded by an earlier cartel in the 1980s.
[111] Sumika was named Yodogawa at this time. It became Sumika in April 1992 when Yodogawa merged with two affiliates spun off from Sumitomo Chemical. Sumitomo owns a controlling interest in Sumika.
[112] In 1993 and 1994, the gap between the two prices narrowed to about 2%.
[113] These regions accounted for 33.0%, 36.4%, 3.0%, and 27.5%, respectively, of the quantity consumed worldwide in 1991.

business with bulk vitamins at the cost of production, it could undersell its premix products and squeeze rival premixers out of the market. Because the Japanese members of the cartel received no such benefits, Roche's strategy caused some tensions early during the cartel's life.

Events in the cartelized folic acid market unfolded in a manner reminiscent of vitamin B1. Folic acid prices took off from the first year of the agreement until mid 1994. U.S. prices rose by 40% in that three-and-one-half-year period. The cartel's downfall began in late 1993. Until that year Chinese production had never accounted for more than 3% of global supply. However, like a few of the other water-soluble vitamin cartels, Chinese manufacturers had in the early 1990s solved technical production problems and were rapidly scaling up output and exports. From 1992 to 1993 Chinese production exploded, increasing by 700%. By 1994, Chinese producers accounted for more than one-third of global production.

At its meeting on September 24, 1993 the three Japanese firms identified growing Chinese exports as the main cause of falling folic acid prices. In Europe, Chinese imports had reached a level that amounted to 28% of the cartel's planned 1993 volume. Prices began to decline in mid 1994, so the folic acid agreement was formally abandoned at a meeting in Tokyo on June 10, 1994. Five years later U.S. prices had dived by nearly 60% (Bernheim 2002a: 121).

Vitamin B6

This cartel also began with the January 30, 1991 visit of Roche executives to Takeda and Daiichi in Tokyo (EC 2003: ¶330-353). In 1990 these three companies controlled 72% of global sales, the second smallest initial degree of control of any of the vitamins cartels. The pricing pressures facing the three firms in this market were especially severe. From mid 1988 to 1990 the EU price of vitamin B6 declined by 15 to 20%; in the United States, the decline was more than 20%. The major reason prices had declined so precipitously is that a previous cartel that had operated in the 1980s had ended in 1989.[114]

As was the case with so many of the vitamins cartels, the agreements were patterned closely after what had been working so well in vitamins A and E. The three members of the vitamin B6 cartel met pair wise: biennially in Basel (Takeda and Roche) and biennially in Tokyo (Takeda with Daiichi). They agreed to raise minimum prices at least four times: in January 1991 (increase unknown), October 1991 (by 3.5%), April 1992 (by 2.3%), and July 1992 (by 5.6%). In April 1993 the remnants of the cartel lowered its minimum price by 5.6%.

During the cartel's first 15 months prices rose dramatically faster than the agreed prices, but this increase is mainly attributable to three fortuitous events. In Europe the price rose from DEM 51 in the first quarter of 1991 to DEM 85 by March of 1992, an increased of 67%. In the United States, the comparable increase was 60%. The main factors responsible were the withdrawal of two significant suppliers (BASF and E. Merck) in early 1991 and the closing of an old plant by Daiichi in August 1991.[115] Daiichi's new plant did not start up until March 1992. Therefore, from January 1991 to March 1993, only a portion of the 1991 increase was due to the cartel's conduct. After Daiichi's new capacity came on stream, EU transaction prices continued to rise by only about 2% to the peak in early 1993. Prices held steady until July 1993, after which they fell precipitously.

Daiichi and Chinese producers were the spoilers. Roche wanted to meet with Daiichi in the spring of 1993, but Daiichi would not comply. When Takeda and Roche met in Basel on

[114] Vitamin B5 also had a prior cartel (see next section). Whether cartels existed in the 1980s for any other vitamins is not known, though structural conditions certainly favored them.

[115] The shut-downs of the BASF and E. Merck plants look suspiciously timed. Both companies had produced vitamin B6 since 1982, reaching global shares as high as 11 and 16%, respectively. When their production ended, as if by prior arrangement, Roche absorbed all of production the next year. Their simultaneous withdrawals could have been part of a side agreement to another cartel.

May 25, 1993, Takeda reported that Daiichi was trying to maximize the amount it could sell, disregarding the cartel's share agreement. Although Takeda's allegations reek of double-dealing,[116] they decided to punish Daiichi by matching its prices. The prices being offered by Chinese companies were even lower, though events in the late 1990s would show that Chinese production was not based on low-cost technologies.[117] Prior to the start of collusion in 1991, Chinese production had languished at below 3% of the world's total. During 1991-1993 Chinese production value rose to 48% of the global total – slightly lower in Western Europe and a bit higher in North America.

The last meeting between Roche and Takeda concerning vitamin B6 occurred in Japan on June 10, 1994; Roche met with Daiichi the last time on June 15th. However, all the participants had recognized earlier that year that the cartel agreement had been ineffective for quite some time. In July 1994 Roche signaled the end of collusion by lowering its minimum DEM price by 28% to meet Chinese competition in the EU; in October 1994, that price was cut another 13%. EU transaction prices fell 60% in 1996 from their 1993 peak and remained at less than half the 1993 level through 2003 (Appendix Table 3); the U.S. market displayed the same post-cartel price movements.

Vitamin B5

Despite the fact that Daiichi was one of its three members, the vitamin B5 (cal pan) scheme was the most durable of the B complex cartels (EC 2003:¶292-329). Like the case of vitamin B6, the vitamin B5 cartel was a rebirth of an earlier conspiracy that had begun in 1985 and had slackened in 1989-1990. However, participants agreed that the earlier cartel did not approach the sophistication of its 1991-1999 successor. The disbanding of the first cartel in 1989 caused prices to decline so low (to about CHF22 or €12 per kilogram) that Roche was selling vitamin B5 at cost.

Roche made overtures to Daiichi about reviving collusion at a Tokyo meeting in late December 1990, proposing to adopt the mechanism and rules used in the vitamins A and E cartels. Implementing the cartel took about six months of negotiations. The first formal meeting among Roche, BASF and Daiichi took place in Basel in the first quarter of 1991; a few months later the firms were exchanging sales data. Using 1990 production as the basis of the agreement, the three companies agreed to set market shares within narrow ranges in Europe and worldwide for the 86% of world supply that they controlled. The decision to adopt quota ranges of about four percentage points was unique among the vitamins cartels; it was a substitute for the compensation sales used in most of the other cartels. In all other respects, the vitamin A model was imitated closely.

The vitamin B6 cartel had a small fringe of firms outside the cartel from Eastern Europe and Japan.[118] The fringe's share rose and fell slightly during the cartel, but averaged only 14% of global sales; entry by fringe exporters was kept to even lower levels in Europe and North America. Within the cartel, the three members observed their agreed quota ranges carefully (Appendix Table 6A). Except for a blip in 1996, Roche held on to a 41 to 45% intra-cartel share,

[116] Takeda seems to have been disingenuous here. True, Daiichi had acquired an additional 1.3 percentage points of the cartel's output in 1993, but Takeda had grabbed much more (4.1 points) (Appendix Table 6A). Recall that Roche had no direct meetings with Daiichi, and depended on Takeda for information on Daiichi's compliance.

[117] It is ironic that when in 1996 1998 selling prices fell permanently 50% below peak collusive prices, Chinese production withered to a mere 10% of world output and the shares of the three former cartel members rose to heights not seen for more than 15 years.

[118] The fringe consisted of one company in Japan (Alps Pharma) with 10% of world production and firms in Poland and Romania with 4%.

and BASF to 21 to 25%. Daiichi – so uncooperative in the vitamin B6 cartel – was an exemplar of self-restraint in the vitamin B5 cartel.

The second vitamin B5 cartel was highly effective in raising prices. EU prices rose by 50% from 1991 to 1993; at the peak in early 1998, prices were 75% higher than the year before the cartel was underway. Similarly, U.S, transaction prices rose to a 1996-1998 plateau that was 80 to 85% above the 1990 price. As with other cartels, the members of the vitamin B5 cartel were active in countering the deleterious effects of international geographic arbitrage. The rule of thumb was to keep prices in one currency zone less than 10% above or below prices in other currency zones, when the two prices are converted into the same monetary unit. If the spread became higher than 10%, then the cartelists figured that transshipment would become profitable.

Roche and BASF at times caused dissent within the cartel because of their strategy of using price increases to squeeze rival premix sellers out of business. In particular, Daiichi, which did not make premixes, objected to a proposed 10% price increase in the spring of 1998 because it judged that fringe producers in Eastern Europe would flood Western Europe with vitamin B5. This would reduce the cartel's market share in straight vitamin B5, but would have benefited the premix operations owned by Roche and BASF.

Meetings of the cartel persisted even after the raids in the United States on members of the lysine and citric acid cartels in June 1995 and even after the U.S. vitamins investigation intensified in 1998.

Vitamin C

In terms of annual sales the vitamin C market was the biggest of the 15 straight vitamin markets, with global sales 54% higher than second-ranking vitamin E (Table 9). Sales of vitamin C were about 85% larger than all five of the B complex vitamins just described. The European Commission provides an extensive narration of the inner workings of this cartel (EC 2003: ¶388-458). The short history of vitamin C collusion resembles that of vitamin B1.

In 1975, Roche and Takeda controlled about 84% of the global market, but 15 years later they shared only 71% (Appendix Tables 5 and 6). Four manufacturers accounted for 87% of the world market for vitamin C in 1990: Roche was the leader, Takeda was a strong second, and E. Merck and BASF shared about one-eighth of world sales. However, the two leaders were not in direct competition with their two smaller rivals. Roche and Takeda emphasized the production of the dominant segment of the market, human-grade product, whereas E. Merck and BASF specialized in animal-grade. The remaining 13% of the 1990 world market consisted mainly of fast-growing, export-oriented Chinese manufacturers of feed-grade vitamin C.

With about 90% of world production and a smaller fringe, the four top producers had carried off a moderately successful cartel in 1995-1989. Prices of human vitamin C had risen by 30% in the United States in the late 1980s, but prices of feed grade had not been so responsive.

The establishment of the second vitamin C cartel was explored a meeting in Basel on April 7, 1990. Top executives of Roche and Takeda met then and on September 4th in Zurich. Prices in Europe had declined by 10% from the previous year and had also weakened slightly in North America. Negotiations must have been difficult, because two more sessions were required to nail down the details: a Swiss meeting among Roche, BASF, and E. Merck in early January 1991 and a final one in Tokyo between Roche and Takeda officers on January 30th and 31st. The finalized agreement incorporated a familiar set of features: freezing the four producers' 1990 global shares of the "available market" (i.e., the 87% they controlled), four tiers of

management and control, and setting target and minimum prices.[119] Meetings occurred quarterly, alternately in Basel and Tokyo. Takeda met bilaterally with Roche, as was its habit in four other cartels, until a May 1993 meeting at Zurich Airport.

One aspect of the vitamin C arrangements that set it apart from the other cartels was the extensive attention paid to several large customers. Buyer concentration was higher in this market than the other vitamin markets. The purchases of these "key clients" were individually allocated, sometimes exclusively and sometimes jointly, to one or two of the cartel members. Examples of such "key accounts" are Coca Cola, Pfizer, Kellogg, Bayer, Astra, Puratos, and Kabi Pharmaceutical. The minutes of the cartel's November 10, 1993 meeting record a detailed scheme to rig bids for Coca Cola in several major markets.[120] At later meetings, the cartel managers indicated that their rigged prices for Coca Cola should be carefully calibrated across countries so that the company could not engage in international *intra-firm* geographic arbitrage. "If this were not done, Coca Cola would always attempt to conclude all of its contracts at the lower market price" (ibid. ¶409).

The vitamin C cartel engineered a 30% increase in prices from 1990 to the 1993-1994 peak. Already keen on expanding their world shares, Chinese producers found the higher prices an added inducement to expand sales at a furious pace.[121] Several capacity expansions in plants that used a new low-cost technology had been ongoing for a few years. Most of the product was feed-grade vitamin C, so E. Merck and BASF were especially hard hit by Chinese expansion. The cartel seems to have underestimated the pace of Chinese competition. Already in 1992 the two smallest members of the cartel had sold about 13% less than had been planned in 1991. By 1993 the cartel had lost 29% of the market to fringe producers, and the difficulties of coping with the Chinese challenge became a major irritant at cartel meetings. The Chinese manufacturers had begun to make food- and Pharma-grade vitamin C, and their exports began to hurt Roche's sales.

At an early 1993 session, the cartel considered purchasing a large enough portion of Chinese-made vitamin C to stabilize prices. Instead, consistent with the general policy of "price before quantity," Roche proposed price increases of about 4% for each quarter of 1995 and an immediate 5% cut in cartel production; the others agreed to abide. In April Roche announced the planned price increase. In a May 1993 meeting of the four participants, Takeda argued that it should have only a 2% cut in its 1993 volume, rather than the 5% it had agreed to a few months before. Its position was that Chinese production was primarily targeted at the feed-grade segment of the market, so BASF and E. Merck should accept larger quota reductions. However, in the end a compromise was reached that the European members would take 2.5% cuts and Takeda a 2.2% cut.

Despite the stress on the cartel from fringe entry, its internal market-sharing agreement proved to be remarkably robust. Throughout the 1991-1995 cartel period, Roche strictly adhered to its 51 to 53% share of cartel production, Takeda never wavered from a 29 to 31% share range, and the two smaller members stood by their quotas (Appendix table 6A).

The Chinese incursion intensified later in 1993, and by the end of the year prices began to drop quickly. In their August 1993 meeting, the European members of the cartel renewed their call for a 5% across-the-board reduction in sales volume, and Takeda once again

[119] In most of the other cartels the "lowest" prices were 5% below list, but in vitamin C the spread was 7 to 9%, which may be an indicator of the relative weakness of this cartel. Unlike some of the other agreements, no regional quotas were set for vitamin C. Roche wanted them, but Takeda resisted.

[120] Some of the supply contracts contained price-protection clauses that allowed buyers to buy at an old price for a month or two after a price increase was announced. Such contracts are standard features in many chemical industries and may well have applied to other vitamin markets.

[121] Takeda was also expanding aggressively in the early 1990s. At the beginning of 1993, Takeda was found to have exceeded its 1992 quota by 4%. The other three members of the cartel were under their quotas by from 4% to 14%.

demanded greater percentage cuts for BASF and E. Merck. This time it was vociferously rejected by the others; indeed, they threatened to dissolve the cartel if Takeda did not comply. Takeda then temporarily backed off of its demand. The adjusted quotas for 1993 assumed that the cartel commanded only 74% of global production – a fairly accurate appraisal for the first half of 1993. Takeda returned to its complaint about equal percentage reductions in a November 1993 cartel meeting, but was once again rebuffed. Although it ostensibly remained an active cartel member until the end, Roche began to see more and more evidence of Takeda's cheating in 1994. From the year before the cartel to 1994, Roche lost nearly one-fourth of its global market share. The combination of price cutting by Takeda and the Chinese producers caused EU transactions prices of vitamin C to decline by 33% from the end of 1993 to 1995.[122] In Europe, prices in 1996-1999 were 45% below the peak.

The vitamin C case illustrates the difficulty of identifying precisely when a cartel ends. Although Takeda only pretended[123] to adhere to the cartel agreement from sometime in 1994, the three European members probably continued to observe their relative quotas throughout 1994. The last formal meeting of the vitamin C cartel took place in Hong Kong on August 24, 1995 -- long after all its members has quit cooperating on prices or observing their quotas. Roche claims that it renounced its involvement in the conspiracy at about that time, but this assertion cannot be confirmed by any other evidence. Oddly, however, the four companies continued to exchange sales information and set regional prices at the August meeting. Market projections were updated through December 1995. Guilty pleas registered in U.S. courts assert that the end of the conspiracy was the fall of 1995; pleas in Canadian courts admit to December 1995. The European Commission concluded that the precise date of termination is unclear, except to suggest that it certainly had ceased effecting prices by mid 1996. For the purpose of calculating its fines, the EC employs an August 1995 date.

Biotin (Vitamin H)

In the early 1980s, the global biotin industry consisted of one dominant firm, Roche, and two others, Sumitomo and E. Merck. This pattern suggests that the technology of production was a formidable barrier in the 1980s. In 1980 Roche had a near monopoly of 86% of global production, but by the time a cartel was formed in 1985 its share had slipped to 79%. Sumitomo's aggressive expansion in the early 1980s had brought about a precipitous decline in biotin prices of nearly 60%. During the first three years of collusion, prices rose 45%, but this rise represented only about one-third of the 1980-1985 loss of price. The cartel of 1985-1990 was a weak one with no strict market quotas. Not only did Sumitomo's market share expand during the collusive period, but Tanabe entered on a large scale in 1986 and doubled its global share to Sumitomo's level by 1990. A fifth firm, South Korea's Il Sung opened a plant in 1988 that would eventually supply up to 8% of the world's biotin. The last company to enter the industry, Lonza of Switzerland, opened its plant in 1990 capable of supplying 9% of world demand in the 1990s. This onslaught of new capacity drove down the biotin price from mid 1988 to early 1990.

Thus, by 1990 the world market for biotin had six good-sized manufacturers. When the cartel of 1991-1995 was formed, Roche had 47% of market sales, but there were four other

[122] The rapid growth of the Chinese vitamin C industry continued throughout the 1990s. By 2000 its share of the world market for human-grade vitamin C reached 24% and of feed-grade 41% (UKCC 2001: Table 2.1).

[123] Three cartels in which Takeda participated (B1, B6, and folic acid) ended in mid 1994. However, Takeda was still a member in good standing in the vitamin B2 cartel until late 1995, so a precipitous formal withdrawal from the vitamin C agreement might have undermined its continuing benefits from the B2 cartel.

companies with global shares that averaged 12% that joined the new cartel (Appendix table 6). These five participants constituted the largest number of conspirators of any of the vitamin cartels. These five manufacturers of biotin controlled 95% of global sales in 1990, and they would hold on to that percentage for the duration of the cartel. BASF became a member of the biotin cartel by proxy. Unlike most of the other vitamins cartels, no new entry into biotin production took place at any time from 1991 to 1998. The difference between a four-firm cartel and a six-firm cartel with a small fringe and no threat of entry would seem to be slight. Yet, the biotin cartel would prove to be one of the most fragile of the vitamins conspiracies.

The decline in the price of biotin in 1988-1990 prompted the reestablishment of overt collusion (EC 2003: 47-50). Initial contacts were made by Roche and the Japanese chemical firm Tanabe in March 1991. This bilateral meeting in Japan principally concerned technical matters, but the idea of setting target prices was also broached in an indirect fashion for the first time. A similar meeting occurred in Japan in May 1991 and biennially for four more years thereafter.

In Europe, Roche organized a summit for five firms in Lugano, Switzerland on October 14, 1991. The world's fifth largest producer, Il Sung of South Korea, did not attend. It is not known whether Il Sung was not invited or chose not to attend. It is clear that Il Sung was not cooperating with the cartel, because in 1993-1995 the company had doubled its production from the 1991 level. In January 1993, Roche proposed to its fellow conspirators that the cartel should make a side payment to Il Sung in the form of an offer to purchase all or most of its production. Another seller of biotin was absent. BASF sold but did not manufacture biotin. Under a co-production agreement with E. Merck, BASF obtained its biotin only from E. Merck. Roche ordered Merck to represent BASF's interests in the cartel.

Participants at the Lugano meeting included representatives of Roche, Lonza of Switzerland, Sumitomo Chemical, Tanabe, and E Merck. Roche was blunt with E. Merck, which was practically ordered to attend this clearly collusive meeting. The first order of business was to exchange each firm's previous year's sales volume; because biotin was sold in different strengths, volume was expressed in 100%-biotin equivalents. Shares were broken down for Europe, North America, and the rest of the world. The figures were communicated orally so that there would be no written record. Then, the companies' 1990 production shares were adopted as quotas for the 1992 marketing year ahead with only a few small adjustments. First, 10% volume growth was assumed for 1990-1992. Second, the two largest manufacturers, Roche and Sumitomo, diplomatically agreed to cede about 3% of the 1992 market to the three smallest firms, most of the increase going to Tanabe. Because of a "significant degree of mistrust" among the participants, the agreement on 1992 quotas was not regarded as a long term commitment. It was understood that renegotiations might have to be rescheduled every quarter or every six months. Merck in particular threatened to keep its production steady if it detected that others were exceeding their agreed shares.[124] These quota arrangements were a significant departure from the vitamin A blueprint.

Although the market-share agreement seemed to be makeshift, it would prove to be quite stable in practice. The intra-cartel share of Roche from 1991 to 1995 barely wavered from its original 47% allocation (Appendix Table 6A). The combined shares of the two Japanese firms that had been so expansionist in the late 1980s also barely moved; from 38% in 1991, it climbed gently to 40% in 1993-1995. Only E. Merck's share slid to accommodate the Japanese firms' expansion.

[124] A confidential note kept by BASF referring to agreements made at the Lugano summit states: "*MERCK + BASF will nicht zurückfallen, wenn andere steigen*" ("Merck and BASF will not cut back if others increase") (EC 2003: ¶493). This was also called the principle of "fair burden sharing." In economic game theory, this promise of retaliation resembles a "trigger mechanism."

At Lugano, the participants also agreed to target and minimum prices for biotin to be made effective January 1 1992[125] and to be raised again by 7 to 10% on April 1, 1992 (*ibid.*). List and minimum prices were also set for both a diluted (2%) feed-grade product and a 100%-pure pharmaceutical version. As in other cases, the principle was "price before tonnage." Besides the usual bickering about other members selling at low prices or stealing customers, new price levels and quotas were negotiated about every six months at meetings in luxury hotels in Zurich, Geneva, Nara, Osaka, Tokyo, and similar cities.[126] Sales data were gathered in advance by means of telephone calls. In a departure from the pattern in the other vitamins cartels, the multi-tiered management structure was abandoned. For biotin meetings all the participants were from the top reaches of the companies' management structure. Roche sent its head of worldwide vitamins marketing. The great concern about security and the engagement of top-level executives may have been prompted by an unusually high degree of mistrust.

At the end of March 1994, actual prices being charged in Europe by Roche were meeting the targets set for the first quarter of 1992. However, even Roche's prices were below the hoped-for increases announced for April 1992; in fact none of the participants was close to observing the agreed-upon April 1992 price schedule. Moreover, Lonza was charging biotin prices that were 8% below the January targets, and the two Japanese firms were 11% below. Tanabe would later accuse price-shading by Lonza and Sumitomo for bringing down the cartel. Although the evidence is sketchy, it appears that by early 1994 the cartel was achieving a weak but positive effect on prices in Europe. Using the prices being offered by the maverick Korean manufacturer Il Sung as a benchmark, the members of the biotin cartel were selling on average at prices inflated by 7 to 8%.[127]

In the U.S. market the price of feed-grade biotin barely budged in the 1991-1995 period (Bernheim 2002a:106-107). This was no doubt disappointing to the biotin conspirators because feed-grade biotin accounted for 73% of U.S. affected commerce. However, the cartel had more success with the human grade product. Its prices rose by 15 to 20% from 1990 to 1992-1995. Thus, weighting the two grades together, U.S. prices of biotin also increased by 7 or 8% from more competitive levels. Compared to most of the other vitamin cartels, the biotin agreement produced a weak result, but compared to the prices that had preceded the cartel, the profits may have been satisfactory.

Like the vitamin C cartel, it is unclear when the biotin cartel ceased to function. Roche stated that implementation of pricing agreements ended in early 1994 and that the last multilateral collusive meeting occurred on April 19, 1994. The European Commission comments that after April 1994 "contacts may have been desultory" (EC 2001: ¶514). Tanabe says that it continued to apply the cartel's target prices until January 1995 and that it was given target prices by telephone in December 1994. At a meeting organized "sometime in 1995" by Roche at its new headquarters in Basel, both Merck and Lonza announced that they were no longer prepared to meet. This fact suggests that two of the members thought that the agreement was still in force at least through the end of 1994. Roche officers last met with Sumitomo managers in December 1994, but Roche claims that the discussions solely concerned an unrelated chemical. In the United States, plaintiffs filing private suits claimed that

[125] How much of an increase this represented from pre-cartel prices is not revealed. The fact that the cartel kept meeting for two years or more is some indication that this first price increase was significant.
[126] Officials of Roche and Lonza met bilaterally about biotin when attending regular business meetings; the same was true for Sumitomo and Tanabe.
[127] These data are shown in EC (2003: ¶495 and ¶511). The weights are European volume-of-sales shares. If Il Sung was engaged in umbrella pricing, then the size of the cartel's monopoly overcharge would be higher.

the biotin conspiracy lasted until the fall of 1995. For the purposes of imposing antitrust fines, the European Commission cautiously used April 1994 as a termination date for the cartel.

Even assuming the longest collusive period of 55 months, the biotin cartel was the briefest of the 16 vitamin cartels. Unlike most of the B complex cartels, the threat to cartel was internal cohesion rather than external price competition. The participants were unable to construct the kind of elaborate management structure that contributed to the effectiveness of the other cartels. Despite the unusual dependence of the biotin cartel on the involvement of top executives, the records of its meetings suggest a high level of discord. Because its price effects were relatively weak, it seems to have generated small, if positive profits for its six members. The small size of the competitive fringe was in the end unable to compensate for the strong centrifugal forces associated with large collusive groups.

The determination of the termination date for formal collusion was critical in this case because under EC rules there is a five-year time limit from the date the violation stopped to the date of the EC's first "action." The relevant action date is the day the Commission begins its formal investigation (the day it sends out written requests for information). The biotin investigation began on August 20, 1999 – about three months after U.S. guilty pleas were made public. If the deadline is missed, then the EC cannot impose a fine. In fact, all six companies were guilty, but the time limit was exceeded by *four months,* thus sparing them significant EU fines.[128] Had the Commission decided on December 1994 as the date of cessation of collusion, six fines would have been imposed.

Summary of Vitamins B1 to B9, C, and H

This section discussed the cartel conduct of European and Japanese manufactures for seven of the class of water-soluble vitamins: B1, B2, B5, B6, folic acid, C, and biotin. Five vitamins cartels (A, E, B12, and two carotinoids) had been initiated in late 1989 and early 1990. By mid 1991 the first wave of cartels seemed to be heading for success. The seven conspiracies just discussed comprised the second wave of cartel building by the three founding members of Vitamins, Inc.

Like the vitamin A and E cartels, the second-wave cartels were part of the family of schemes initiated and dominated by the biggest manufacturer, Hoffmann-La Roche, ably assisted by its two willing partners, BASF and Rhône-Poulenc. The cartels for water-soluble progeny displayed a strong family resemblance to the pioneers, but each also displayed some tailor-made individuality. That is, each of the seven cartels was constructed from the vitamin A and E templates, but each was designed with subtle differences to accommodate variation in environmental or compositional variation. The narratives above teased out some of the behavioral differences among the conspiracies.

Cartels without Roche

Vitamin D3

It appears that the Roche-Solvay duopoly operated a vitamin D3 cartel from 1985 to 1988. There was no third producer anywhere in the world during this period.[129] Moreover, prices in the late 1980s display the classic hump shape seen in all successful cartels periods. As was true with all the cartels of the late 1980s, pricing discipline broke down in the year before a new

[128] The biotin case is not unique. The vitamin B1 (three companies), vitamin B6 (three), and folic acid (four) conspirators were all spared fines for the same reason. Thus, 16 potential fines were not imposed.
[129] A small Japanese firm A. L. Labs produced modest amounts of vitamin D3 in 1983 and 1984, but it withdrew from the industry just as collusion began in early 1985.

collusive episode began (Bernheim 2002a: 118-119), though this dip in price was modest and confined to the larger feed-grade segment of the market. One reason that prices weakened in 1989 was the impending entry of a third producer, BASF, which practically overnight went from zero to a 13% global production share.[130]

The formation of the second cartel is a bit mysterious. The European Union was the only government that sanctioned this conspiracy, but it is difficult to imagine that its impact did not spill over into North America (EC 2001: ¶459-483). Moreover, it is a general practice in the dairy industry to fortify milk with a compound containing both vitamins A and D. Because they are complements for some buyers, it would be natural for cartels to be formed for both products. A Roche document discovered in an EU raid dated March 1991 states that vitamin A pricing was to be done in conjunction with vitamin D3 pricing, but Roche denies having originated the D3 cartel. Solvay, on the other hand, blames Roche for instigating collusion.

The European Commission's decision notes that the origins of the vitamin D3 cartel are unclear. Around the time it started a number of structural changes took place. The Belgian chemical manufacturer Solvay was and remains the dominant global producer of vitamin D3. However, Solvay stopped making vitamin A before 1990. At about the same time BASF, then colluding with Roche in the market for vitamin A, began to manufacture vitamin D3. BASF's entry into D3 caused Solvay to lose 25% of its sales in 1990. Moreover, Roche had, after years of doing so, refused to supply Solvay with vitamin A beginning in 1991. Thus, Solvay became unable to sell the vitamin A and D3 compound that many of its customers would want. To all appearances, Roche and BASF actions were placing Solvay in a difficult business position.

Plaintiffs in the civil suit in the United States have a different story about the origins of the D3 cartel. They claim that the second cartel began in January 1990. Two bits of circumstantial evidence support the earlier date. First, despite BASF's large-scale entry in 1990, U.S. prices rose dramatically in 1990 and 1992, by 30% in the feed-grade market and by 25% in human grade. While prices rose from time to time in 1993 to 1998, none of the later increases were close to these magnitudes. Second, market-share stability was almost as high during 1990-1993 as during 1994-1998 (Appendix Table 6A). In the earlier disputed period, world market shares of all three manufacturers were within 2 percentage points of a 43:41.5:16.5 split.

According the EC, the three companies initiated their collusion on January 11, 1994 in Basel, Switzerland (*ibid.*). At that meeting, Solvay, Roche, and BASF agreed to split the feed-grade market in the ratio 41:38:21. This split was not much different from the actual shares in 1993. The pharmaceutical-grade market was split 50:50 between Roche and Solvay. Rhône-Poulenc's interests were represented in the cartel by Solvay, which was Rhône-Poulenc's sole supplier and its quota was included in Solvay's share. In the much larger feed-grade segment, Roche and BASF agreed to shares of about 30% each. Target and minimum prices were set for three regions: Europe, the United States, and the rest of the world. With control of about 100% of world supply, the prospects for a durable cartel were rosy (Appendix Table 6).

Unlike the other vitamin cartels, the D3 conspirators met only twice each year in February and September. Solvay acted as Rhône-Poulenc's agent at the meetings and provided Solvay with its sales data in bilateral contacts in advance of the biennial tripartite meetings. Thus, the cartel had four members, one that participated by proxy. The EC decision states that the cartel raised prices only twice, in April 1994 and in August 1997.[131] BASF was the designated so-called price leader for the first price adjustment and Solvay for the second. U.S. prices hardly reacted to the first announcement and not at all to the second. The anemic

[130] It is not clear that BASF was an entrant in the strict economic sense. When BASF began production in 1990-1991, its rapid ascension to a 17% share corresponded almost exactly to Roche's decline in share. This suggests that Roche transferred about one-quarter to its friendly rival BASF and that little or no *new* capacity was created in the industry. Roche had a history of like gifts to BASF in other vitamins industries.
[131] The size of the first increase is not known; the second was 20%.

price response suggests that the January 1994 meeting was a renegotiation of an existing agreement.

As is generally the case with the oil-soluble vitamins, the vitamin D3 cartel expressed no worries about fringe firms, and in fact the degree of cartel control was 100% for the conspiracy's five to eight years. It did, however, discuss concerns about grand-jury investigations in the United States. Roche representatives brought up the topic at the cartel's August 1997 meeting, telling the others that Roche's management had instructed employees to stop regular meetings. Nevertheless, the four conspirators continued to meet at least three more times bilaterally (Rhône-Poulenc with Solvay, Solvay with Roche, and Roche with BASF) until as late as June 1998. Collusion may have persisted to February 1999.

Niacin and Choline Chloride

Relatively few details have surfaced about the origins and operation of the niacin price-fixing conspiracies. What little is known must be pieced together from court documents containing only minimal facts filed in U.S. and Canadian courts. However, much more is known about the inner workings of the choline chloride cartel because of a trial held in the United States in 2004 and a published decision of the European Commission.[132]

The last two cartels were different in several ways from the others that have been discussed. The participants in the niacin (B3)[133] and choline chloride (B4) conspiracies were almost a completely different set of companies from those in the "Roche cartels." In both cases only one company was a member of both the Vitamin B3 or B4 cartel and simultaneously one of the Roche cartels. In addition, both cartels are unique in having had participation by manufacturers that were headquartered in North America.[134] Moreover, the vitamin B4 conspiracy began having market effects in 1988 – a year or two earlier than the Roche cartels.[135] The vitamin B3 cartels could have started as early as 1986 or as late as the fall of 1991. No other vitamins cartels began on these . The niacin cartel lasted at least eight and one-half years and the North American branch of the choline chloride conspiracy about ten years.

Niacin

The leader of the global niacin cartel was the Swiss firm Lonza, which is loosely part of the Alusuisse conglomerate. Lonza had captured two-thirds of global production in the early 1980s (Bernheim 2002a: 99). In the early 1990s Lonza still dominated global sales from its single plant in Switzerland that supplied almost 60% of global production. Lonza reportedly had a 70% share of European sales (Appendix Tables 5 and 6).[136] The German metals and specialty chemicals company Degussa had a strong and growing second position in the niacin market. Degussa's share of world wide production of vitamin B3 grew from only 8% in 1981, to 21% in 1990, to 27% in the late 1990s. Based on subsequent prosecutions, it appears that Lonza and

[132] The full EC decision of the choline chloride cartel was released in late 2005.
[133] Other names for niacin include Niacinimide, 3-pyridinecarboxamide, Nicamid, Nicotinamide, Nicosedine, Nicotinic Acid Amide, Nicotylamidum, and Vitamin PP.
[134] The U.S. firms are Nepera and Reilly (B3) and Chinook and DuCoa (B4).
[135] Guilty plea agreements of Lonza, Degussa, and Nepera state that their participation began "as early as January 1991." Nepera left the cartel in July 1995, about the time it was sold to Cambrex Corp. Degussa turned over management of the price fixing to its U.S. partner, Reilly Industries, at about the same time.
[136] Roche was reported to have been the dominant seller of niacin in Europe in 1975 (EC 1976).

Degussa initiated discussions to establish the vitamin B3 cartel and later pulled two smaller U.S. companies into the conspiracy.

It is possible that Lonza and Degussa began colluding on European sales and exports to North America in 1985. While the U.S. guilty plea agreements are vague[137] on this point, 1985-1990 U.S. prices (and probably global prices as well) trace the characteristic hump shape associated with an effective collusive period from 1985 to the end of 1988 followed by a pause in collusion from early 1989 to mid 1990. From 1985 to 1988, the two leading firms enjoyed a nearly constant 80% global share that was certainly sufficient to support overt collusion. However, the U.S. private plaintiffs did not claim damages from a late 1980s cartel in vitamin B3, and no EU convictions have been forthcoming. Therefore, the evidence concerning the existence of an earlier cartel is mixed.

A global cartel of four firms certainly operated in global market for vitamin B3 through most of the 1990s, but there is some uncertainty as to the starting date. Two U.S. companies, Reilly Industries and Nepera, joined the two European companies to form the cartel of the 1990s sometime between mid 1990 and early 1992. Price data favor the earlier date. Prices of feed-grade vitamin B3 fell by 25% in the 18 months prior to July 1990 and then climbed 35% in the 18 months following July 1990.[138] No other steep price changes of that kind occur in the 1990s.

Reilly Chemical ran two vitamin B3 plants, a large one in Indianapolis and a smaller one in Belgium. Sometime in the early 1990s Degussa and Reilly became co-owners of a niacin joint venture known as Vitachem, but when the partnership began is not exactly known. Until late 1994, the pricing of vitamin B3 was Degussa's responsibility while Reilly's management confined itself to production decisions. However, in September 1994, Degussa involved Reilly in the conspiracy, which persisted until at least March 1998.

Nepera is a small chemical maker headquartered in New York State; it appears to have sold most of its niacin in North America. Nepera held on to a global share of 6 to 9% throughout the 1990s, but its North American share approached 30%. From the U.S. guilty pleas, it is clear that Nepera had a leading role in the conspiracy beginning by at least January 1992. In July 1995, about the time it was acquired by Cambrex Industries, Nepera withdrew from the U.S. conspiracy. Cambrex was never charged with any wrongdoing. So, from July 1995 to March 1998, Lonza and Reilly continued with U.S. price fixing on their own. However, without Nepera's support, U.S. prices did begin a slow slide until the end of collusion in 1998 and continued to fall for two or three more years.

There are few signs if stress in the B3 cartel. The cartel was protected by technological barriers and operated in a highly concentrated industry. From 1990 to 1998 the four top vitamin B3 manufacturers controlled 86 to 95% of global supply. During the three-firm stage of the cartel, intra-cartel market shares were quite stable (Appendix Table 6A). Lonza maintained a 65 to 67% cartel quota in most years, Degussa-Reilly 24 to 26%, and Nepera 10%. Lonza and Degussa loosely coordinated the vitamin B3 conspiracy with the main group of vitamin price fixers associated with Hoffmann-La Roche (Barboza 1999). Even after Nepera left the cartel, the remaining three conspirators held on to 84 to 86% of global supply and maintained their 1991-1995 production quotas. Fringe firms did not expand during the collusive period, and small-scale Chinese production did not begin until 1997.

[137] They state that Lonza began fixing prices "as early as" January 1992, which is a formula used by federal prosecutors

[138] Prices of human grade acted in the same manner except that the percentage changes were lower.

Choline Chloride in North America

There would be three distinct price-fixing conspiracies formed in the markets for choline chloride (vitamin B4).

The first choline chloride cartel began at a meeting in Toronto, Canada in January 1988. There the longtime vitamin B4 sales manager for Chinook, Ltd. (Russell E. Cosburn, employed from 1967-1992) hosted a meeting of the other two manufacturers of the vitamin in North America: the Cleveland, Ohio firm Bio-Products (owned by Mitsui of Japan) and DuCoa of Illinois. DuCoa was formed in 1987 as a joint venture of DuPont and ConAgra. DuCoa's principal line of business was choline chloride, which accounted for about one-third of its sales. ConAgra was assigned principal management responsibility over DuCoa.

North America was the locus of the largest vitamin B4 supply in the world. The three manufacturers controlled 47 to 49% of global production in the mid 1990s (Appendix Tables 5 and 6), and before the global cartel was formed in 1992, their exports to Europe accounted for 9% of European demand.[139] The five European producers shipped little choline chloride to North America in 1991, so it appears that the three U.S. and Canadian firms were more efficient than their European counterparts.

At the Toronto meeting, the three North American companies agreed to raise the North American list price of choline chloride, to allocate specific customers, to rig bids, and to share the market equally. By the spring of 1989, market prices of choline chloride began to rocket upward – by 40% above 1987 levels in the first year and by 60% at its peak in 1995 (Bernheim 2002a: 92). Thus began the "North American branch" of the global choline chloride cartel. In general, U.S. prices of choline chloride remained 40 to 65% above 1987 levels for the entire ten years of effective collusion. Prices did decline modestly from the 1995 peak through 1998, but they remained well above pre-cartel and post-cartel levels.

In 1997 DuCoa was acquired by another company named DCV. Based on the convictions in the United States and Canada, it appears that DuCoa's mid level sales managers continued to collude before and after DuCoa's acquisition without the knowledge of DCV's management. Neither DuCoa's old parents nor its new one were charged with price-fixing violations, but as the managing partner of DuCoa, ConAgra was held responsible for DuCoa's damages in U.S. civil suits. Lack of involvement of top executives is another feature of the choline chloride cartel that sets it apart from the Roche cartels.[140]

The only criminal trial involving a participant in the vitamins cartels took place in U.S. District Court in Dallas, Texas in 2004 (Barnett 2005: 6-16). The defendant was Daniel T. Rose, former President of DuCoa, who was found guilty by a jury and sentenced to 30 months in prison in March 2005. Five of Rose's co-conspirators testified against Rose. The trial record provides some tantalizing insights into cartel conduct.

More than 20 to 30 face-to-face meetings were held in the Midwest from 1988 to 1998. The agendas usually involved reviewing market sales trends, planning to rig bids and thereby allocate major customer accounts, raising or maintaining list prices, and assigning one of the three to make the first price announcement to the trade press. As the former president of DuCoa would later testify:

> "The conspiracy was our way of life….that's what we had to do to sell the product and make the money we were making." Barnett 2005:16).

[139] North American exports to Western Europe rose from 71 tonnes in 1989 to an annual rate of 3,418 tonnes in the first half of 1992, an annual rate of increase of 144% (EC 12/9/04: 24-25). Chinook was by far the largest exporter in 1989 to 1992. Bio-Products shipped significant amounts, but DuCoa very little.

[140] This comment applies to DuCoa and Bio-Products. It seems likely that the president and CEO of Chinook was part of the conspiracy, but he was not indicted.

The three companies "had a spat from time to time," frequently accusations of poaching particular customers (*ibid.* p.9). However, poaching was not a sign that their agreement was in jeopardy; rather it signaled the desire for a meeting to renegotiate the "protected customers" list. Each supplier's customer portfolio would be reconfigured on a regular basis to maintain the agreed sales quotas.

For example, in the fall of 1997 DuCoa and Chinook were concerned about Bio-Product's rising market share. In response, their representatives decided to implement a "Trojan Horse strategy." DuCoa would sell a large amount of choline chloride at a favorable price to a chemical wholesaler named South Central Products. In late 1997, Chinook and DuCoa bid high on a tender for one-third of Tyson Food's substantial choline chloride needs, which allowed South Central to win the Tyson contract. That business had been previously allocated to Bio-Products, so the Bio-Products manager angrily insisted on a meeting. In January 1998, officers of the three companies met over dinner on the fringes of the Southeast Poultry Convention in Atlanta to discuss the engineered rift. At a follow-up meeting at the O'Hare Airport Hilton hotel in Chicago, DuCoa and Chinook and DuCoa offered compensation to Bio-Products for the loss of its Tyson business. In particular, DuCoa offered to turn over its Roche[141] account to Bio-Products, and Chinook offered it account with Cagle's. Rose's lieutenant Antonio Felix later testified that "…[T]he idea was to see how we can compensate …the balance that Bio-Products had lost with our takeover of Tyson" (*ibid.* p.13). Bio-Products apparently accepted the trade, thus ameliorating the brief tempest.

At the end of the Chicago meeting the conspirators decided to raise list prices by 4 to 5 cents per pound for liquid choline chloride and by 3 cents for dry product. This price increase of about 6% was to be effective on April 1, 1998. One of the companies was assigned to contact *Feedstuffs* magazine with the news. After the meeting, the attendees were careful to cover their tracks (*ibid*. p. 15). The Bio-Products manager falsified his travel-expenses report by saying that he met with customers; similarly, the Chinook representative claimed in his expense report that he had met with Continental Grain; and the DuCoa president ordered his assistant to report that they were in Tennessee rather than Illinois.

At a third meeting at the TWA Ambassadors Club at the St. Louis Airport on March 9, 1998, the conspirators met to confirm that the proposed customer trades had been carried out and that prices had been duly raised by all. Both changes had gone off smoothly and effectively. Despite the stated objective to fix North American shares equally, there were some fairly large shifts in intra-cartel positions (Appendix Table 6A). Although Chinook's share of 1989-1998 U.S. sales was fairly constant, Bio-Product's nearly doubled and DuCoa's was cut by more than half.

The St Louis meeting was one of the last to be held by the North American branch of the choline chloride cartel. In June 1998, Bio-Products suddenly withdrew from the cartel, and in September FBI agents raided the offices of the remaining companies. The post-cartel plunge in choline chloride prices was the most dramatic of all the cartels; from July 1988 to January 1989, prices fell 40% (equivalent to an 80% annual rate).

The Global Choline Chloride Cartel

Fast-rising European imports of choline chloride in 1989-1992 alarmed the North American manufacturers (EC 12/9/02). However, the event that that triggered the formation of the global cartel was an aggressive move by DuCoa into the Mexican market.

The three big European makers of choline chloride were BASF (plant in Germany), Akzo Nobel (the Netherlands and Italy), and UCB (Belgium). In the mid 1990s these three companies

[141] It is ironic that the largest vitamin cartelist in the world was simultaneously the victim of price fixing by one of the smallest.

supplied 35% of global demand and 78% of EU consumption. In the 1990s, they built plants abroad: BASF in Mexico, Brazil, and Thailand; and Akzo and UCB each built plants in China. The first choline chloride plant[142] built abroad by any of the North American producers was DuCoa; it began production in Mexico in early 1992 even though BASF already had a plant there. DuCoa goaded BASF further by announcing that it intended to take 40 to 50% of the Mexican market. BASF retaliated by arranging to sell under favorable terms 400 tonnes of choline chloride to the United States from its plant in Mexico in early1992. The effect would be to reduce the North American cartel's high prices.

To address this problem, DuCoa and Bio-Products officers met with BASF managers in Mexico City in October 1992, in order to "…complain about [BASF's] pricing and to suggest setting limit prices in the US."[143] A month later, at a second meeting in Mexico City, BASF agreed to stop exports to the United States, close its Mexican plant, and purchase its entire local supply from DuCoa's new plant. The *quid pro quo* for BASF's capitulation became clear at a summit of the big six manufacturers at the third Mexico City meeting in October 1992. There they all agreed to cease exporting from the United States or Canada to Europe and *vice versa.* To finalize the details of the global cartel, the six met again in November 1992 at the headquarters of BASF in Ludwigshafen, Germany. The six companies affirmed their intentions to stop exporting to each other's continents, to allocate exclusive world sales territories, and to raise the price of choline chloride all over the world.

The Ludwigshafen protocol was quite specific (*ibid.:* 28-34). North America exports to Western Europe would cease by June 1993 and exports to Eastern Europe by June 1994. The three European members would stop all exports to North America by June 1993, and BASF would close its Mexican plant by the same date. By 1994 each sub group would have hegemony over its respective continent.

Latin America and Asia were the world's two fastest growing markets for choline chloride. In Latin America BASF would be compensated for its losses in Mexico by permitting it to open a new Brazilian plant and use that plant to capture all future demand growth in that region. The remaining five manufacturers agreed to freeze all exports to Latin America at 1992 levels. In Asia, the plan was to allow Chinook and Bio-Products to capitalize on all future growth in that continent. The other four produces would hold exports to Asia to no more than 375 tonnes. Production quotas were expected to stay roughly constant, but no precise market shares were specified. Production levels were to be audited by CEFIC, the large European chemical trade association. As for prices, three increases were planned for January of 1993, 1994 and 1995 to $0.66, $0.73, and $1.05 for full container loads, respectively; U.S. prices were expected to be about 5% less than those targets.

The six continued to meet as a group from January 1993 to April 1994 in Atlanta, Amsterdam, Toronto, Bruges, and Malaysia. At the April 1994 last meeting Chinook announced that it would no longer attend meetings of the big six. After April 1994, DuCoa and some of the other companies no longer met about the global arrangements (EC 2004:35). However, to monitor the territorial-exclusivity agreement continuous bilateral contacts were maintained throughout the 1990s. UCB and Chinook in particular met frequently to ensure the smooth operation of global partitioning).[144]

Several indicators began to reveal the global cartel was not living up to expectations. Global price increases were less than had been hoped. Prices in the United States averaged

[142] Chinook constructed a choline chloride plant in Singapore around 1997.
[143] Quoted from BASF's submission to the European Commission dated June 15, 1999 (EC 12/9/2004: 25-26).
[144] See also *In Re: Vitamins Antitrust Litigation, Misc No. 99-197 (TFH), MDL No. 1285).* In its submission to the EC, UCB claims that it was no longer "informed" or "invited" to any global-type meetings (EC 2004:¶96).

about $0.73 per pound (100% basis), which was the cartel's planned price target for 1994, but apparently EU prices were not as high. In Europe there were three "converters," small companies that purchased liquid choline chloride and prepared dry versions on silica or grain bases. Control of the converters selling prices was proving difficult.[145] Considerable dissention arose when Chinook opened a new plant in Singapore in April 1994. In late 1994 DuCoa itself started to undermine the prohibition against exporting from North America to Europe; Mexican exports grew from 66 tonnes in 1994 to 1000 tonnes in 1997-1998.

Although there were no more six-party talks after April 1994, smaller groups and some bilateral meetings were held between members of the North American and European branches until as late as December 1996. This date may be taken to mark the end of cooperation between the two branches. Choline chloride prices slipped a bit from 1995 to 1997, but plunged by 40% from 1997 to 1999. By the early 2000s prices were so low that BASF and probably other producers were suffering from negative operating profits on chlorine chloride sales (EC 2004:68).

Choline Chloride in Europe

The "European branch" of the choline chloride conspiracy was the last to be formed. It was far more tightly organized than the two others that preceded it. The three leading European manufacturers stated to the EC that they began agreeing to global price-fixing at a meeting in Ludwigshafen, Germany in November 1992.[146] At the European level, the cartel may have been launched as late as a meeting in Schoten, Belgium on March 14, 1999. Thereafter, meetings were held in various cities in Belgium, Germany, and the Netherlands every three months and telephone calls every week or two. The specific locations and persons attending the 16 meetings are known from minutes supplied by the three companies (EC 2004: 35-36). Most of them were scheduled immediately before or after the regular meetings of CEFIC, the large European chemical-industry trade association. Target contract and spot prices were specified in local currencies for various grades of choline chloride.[147] Prices were set for four quarters in advance. Besides raising prices, the European branch allocated specific customers to one of the vitamin makers. Shares in the EU were set at 35% for Akzo, 28% for UBC, and 15% for BASF; actual shares tracked these allotments closely. A compensation system was implemented to punish cartel members that exceeded their quota. At the meetings confidential business information was shared about customers, sales, and prices.

The European branch of the choline chloride cartel was apparently still colluding effectively until its last meeting in October 1998. It disbanded only after prosecutions of the vitamins cartel erupted shortly thereafter in the United States. In fact, a Dallas, Texas grand jury had begun investigating the choline chloride market about six months previously. Moreover, the largest U.S. manufacturer began cooperating with DOJ investigators in June, and the other two North American members of the cartel had been raided in September 1998. The fact that a European meeting took place at all in October is testimony to either risk-loving behavior or to the wide separation of the two branches of the chlorine chloride cartel.

[145] Akzo raised its prices of liquid so high to one converter that it had to change suppliers; another was so troublesome that Akzo purchased it. A third converter in Mexico supplied by DuCoa began to export to Europe.

[146] The small Spanish producer Ertisa may have overtly cooperated with the cartel, but the EC judged that the evidence of Ertisa's involvement was not compelling (EC 12/9/04: 59). The U.S. manufacturer Air Products, which purchased a European plant from ICI during the cartel period, was definitely cleared of active involvement.

[147] The grades were specified by percentage of pure vitamin and whether liquid or dry; dry products could be silicon- or grain-based.

CHALLENGES TO COLLUSION AND RESPONSES

Like the I.G. Farben cartel in the 1930s, the vitamins cartels employed almost every trick in the price-fixer's book. Large managerial resources were expended on complex price-fixing structures. After getting underway, in order to continue to be effective a cartel must deal with five problems: reconciliation of disparate member interests that may require renegotiation of the agreement, adaptation to a changed environment, unilateral defection (secret price cutting by members), entry by nonmembers, and avoiding detection by either customers or antitrust authorities. The purpose of this section is to pull together examples of conduct in the vitamins cartels that addressed these problems.

Renegotiating Agreements

It is virtually impossible to write a contract that has clauses to handle every eventuality, and cartel agreements are no exception. There are many recorded instances of flexible behavior among the cartelists that helped resolve disputes and thus preserve the fruits of collusion. The first example is the re-establishment of the 1985-1988 cartels. Roche and BASF learned from the breakdown of those agreements, principally by working out new rules and management structures for vitamins A and E in 1989-1990. These cartels became the models, but not all of the details were adopted for every other vitamin cartel.

Quarterly meetings were standard for most of the cartels. At these face-to-face meetings prices and quotas could be adjusted, anger could be vented, and solutions devised. The cartels almost always involved top managers with the authority to implement significant changes in a cartel's strategy. When prices did not respond sharply enough, it was not unusual for the original members to recruit new members, such as when Eisai was added to the vitamin E cartel after one year. To attract new capacity to the club, the leading members would at times diplomatically yield some of their production to give the newcomer an increase in its production. Roche went to great lengths to accommodate BASF's desire to replicate most of Roche's broad product line; the long-term deal in carotinoids was only the most extreme example of Roche's generosity. Of course, it made sense for Roche to keep BASF happy, because BASF was in the strongest position to retaliate.

In general the vitamins cartels did not engage in rigging bids, but because the vitamin C market had a few large buyers, an exception was made. The geographic regions selected for setting different prices usually was limited to three (Europe and the Middle East, North America, and the rest of the world). However, some cartels identified up to five price zones. If production was interrupted, such as the fire at Rhone-Poulenc's vitamin E plant, the cartel seized the opportunity to raise prices far higher than had been planned a few months earlier.

Monitoring Adherence to Quotas

Checking prices on transactions was not feasible, so the major technique for detecting cheating was for the members to share their internal production records with each other at the quarterly meetings. These data were used to compute company shares globally or in some cases regionally. Shading price would be revealed by a market share in excess of an allocated quota.

Occasionally such data would not prove to be sufficient, and they would be supplemented with government export data. The members knew the location of each member's plants and frequently a country would have only one plant, so a surge in national exports could serve to cross-check members' production claims. Takeda was confronted with such evidence in the vitamin B2 cartel. Another related technique used in the choline chloride cartel was to

create exclusive territories for two semi-autonomous branches. Trade data would detect departures from the hegemony agreement.

Even the best-intentioned criminals will exceed their grasp. Therefore, most of the vitamins cartels had compensation policies. Whenever a company exceeded its quota, that firm was obligated to sell the excess production at cost to an under achiever in the cartel. Resale of the transferred product would restore the planned division of monopoly profits. It is an understanding of this sort that makes increases in interfirm, intracartel sales an indicator of cartel activity.

Punishing Cheaters

Roche frequently took upon itself the role of the bully in a cartel. In clear if softened language, the EC decisions refer to multiple displays of anger directed by Roche representatives toward alleged cheaters.[148] In mid 1993 Roche thought that it had evidence of cheating in the vitamin B5 cartel; Roche and Takeda decided to punish Daiichi by matching the latter's price cuts.

The vitamin cartels rarely employed two punishment strategies suggested by cartel theorists. One method of disciplining putatively uncooperative cartelists is to instigate a price war. At the end of the first wave of cartels in the late 1980s, mild price wars may have occurred, but in the collusion of the 1990s nothing like full-blown wars occur. Another approach to instilling cartel discipline is the "trigger mechanism" – a threat announced at the beginning of a cartel to revert to competitive pricing if cheating is detected. Only in one cartel history is such a threat cited – that of E. Merck in biotin – but it is not particularly credible as it was a small producer.

Dealing with Arbitrageurs

The managers of Vitamins Inc. were well aware that international geographic arbitrage was capable of causing prices to fall below some optimal level in one of its regions. Vitamins are storable commodities, cheaply transported, and subject to unanticipated price changes because of multiple currency regimes. The vitamin B5 vignette is the clearest example of the cartelists' fear of arbitrage. The rule adopted was to keep price in one currency zone less than 10% above or below the prices (when converted to a common currency) in all other currency zones. If the geographic price spreads were kept below 10%, international transshipment would not be profitable. Exactly the same point was made in an internal Roche memorandum to its vitamins A and E sales managers. And in the vitamin C cartel, the Coca Cola Company was identified as a likely arbitrageur were vitamin C to become under priced in any part of the world.

Containing Aggressive Fringe Producers

The record is rather incomplete, but various tactics were employed to try to inhibit the expansion of fringe production, not all of them successful.

Testimony to the European Commission admitted that even in cases where the fringe was miniscule, the cartels considered measures to eliminate imports from fringe producers. Most of the exports were initially of low quality suitable only as feed grade, and there are statements that the cartels price discriminated against this grade. That is, they developed sub standard products or sold feed-grade vitamins at a significantly lower price on a 100% basis than the human grades that had less fringe competition. Another trick was for Roche and BASF to raise the prices of selected straight vitamins because rival premix makers would then be at a

[148] A personal communication to the author by a plaintiff's lawyer alleges that Roche executives had accompanied such accusations with loud shouting and throwing of heavy objects at his client.

price disadvantage in premixes compared to Roche and BASF. Indeed, there are statements in the record that suggest that the intent was predatory. In the vitamin B5 market this strategy caused Daiichi to complain to Roche and BASF about excessive selling prices. Finally, side payments were at times proposed to deal with troublesome fringe rivals. In 1993, Roche proposed that the biotin cartel purchase all of Il Sung's output as a way of boosting prices.

Perhaps the most blatant example of rival containment is Roche's 1981acquisition of the Danish vitamin maker Grinsted. This manufacturer had global production shares large enough to foil effective price fixing in the markets for vitamin C, B1 and B6. A few years later Roche and others formed cartels in all three markets. There are similar anomalies in other industries. E. Merck, Glaxo, and other European producers with seemingly snug positions in the vitamin B2 and B12 industries suddenly and conveniently exit just before a new cartel begins operations.

The vitamin conspirators were feckless in the face of many fringe producers. ADM's obstinate refusal to play ball in the vitamin B2 market is one example. More numerous are failures to co-opt the Chinese producers.

Maintaining Secrecy

The members of the vitamins cartels went to extraordinary lengths to hide their activities. The announcements about price increases were by pre-arrangement rotated among sellers to give the false impression of mere price leadership. Sensitive data on production levels was reported verbally at meetings so as to avoid a paper trail. Many incriminating documents found in raids were supposed to be destroyed. Misleading information was given to in-house counsel trying to detect illegal behavior. False testimony was given to government investigators so as to stymie investigations. When investigators were close to discovering business records about the conspiracies, the participants turned to storing cartel records in unlikely places beyond the reach of the authorities.

ENDGAME: THE CONSPIRACIES UNRAVEL

As mentioned above, there were wheels within wheels. Working groups organized around various combinations of vitamins and their principal suppliers were formed, each of which can rightly be identified as cartels themselves. The vitamin B3 and B4 cartels discussed below were operating on nearly separate tracks from their start, but the remaining working groups were overlapping and strongly interconnected. The difference between the interlocking cartels and a Swiss watch is that when one cartel wheel broke, the other parts kept spinning.

A high proportion of the Roche cartels' meetings took place in Switzerland and Japan. Swiss cartel laws exist on the books, but in the 1990s the Swiss antitrust authority rarely prosecutes international cartels, could only impose fines if a cartel has been previously warned, and metes out only modest fines in any case. Japan' Fair Trade Commission operates in a similarly shy fashion. Thus, the members of Vitamins Inc. must have felt comfortable meeting in Japan and Switzerland. However, cartel meetings also took place occasionally in Germany, France, and other European venues. The European Commission did not learn about the conspiracies until the U.S. DOJ made them public in May 1999. The vitamins cartel brushed off a 1993 raid by French competition authorities as inconsequential, a correct judgment as it turned out. The companies in Vitamins, Inc most feared discovery U.S. Justice Department and its investigative arm the FBI. As a consequence, they avoided meeting on U.S. soil and took other steps to hide their meetings.

Causes of Death: Natural or Legal?

The 16 vitamins conspiracies ended in one of two ways. One set of cartels sowed the seeds of their own destruction by raising prices in industries where the members of the cartels could not prevent the market entry and expansion of fringe producers. The elevated prices gave even inexperienced or inefficient vitamin manufacturers sufficient expected profits to justify investing in plant capacity. In most of these cases the fringe producers were located in China. It is possible that the firms that formed these cartels underestimated the competence of their potential rivals or overestimated their own abilities to cow or co-opt the outsiders. It is also possible that the collusive groups knew that their collective market power would erode after a few years of high prices, but reasoned that a few years of handsome profits were better than a continuation of pre-cartel conduct.

The second and more numerous set of vitamins cartels was terminated by private and government investigations in the United States of allegations of illegal price fixing. Credible complaints by vitamin premix companies about the putatively predatory behavior of the two dominant sellers, Hoffmann-La Roche and BASF, triggered a private investigation by an intrepid class-action law firm in mid 1997. The results of the private investigation were shared with DOJ prosecutors who decided to reopen an investigation of vitamins price fixing out of their Dallas, Texas regional office. The big break in the DOJ investigation came in late 1998 when Rhone-Poulenc, the world's third-largest vitamin firm, decided to take advantage of the Division's relatively untested Corporate Leniency Program.[149] This program offered nearly automatic amnesty for qualified price fixers on condition that the applicant provides sufficient evidence of illegal collusive behavior about which the DOJ was not aware.

It is noteworthy that none of the vitamins cartels ended because of a breakdown in internal cohesion. Disagreements among cartelists are inevitable, but the dissention among the members of the vitamins cartels never reached intolerable levels. As far as is known, Rhone-Poulenc was not unhappy with its market share or the financial performance of the cartels in which it participated. Nor did any other participant in the vitamins cartels actually stop cooperating and either complain to competition authorities or become an aggressive, price-cutting outsider. In other words, absent legal intervention the second set of more durable cartels might have continued indefinitely.

Short-Lived Cartels

Six of the vitamin conspiracies ended relatively soon because producers outside the cartel cut prices and captured large shares of the market.[150] The impact on five of the cartels from fringe competition was significant. Because the cartels lost their grip, the conspiracies in these five markets proved to be relatively fragile.

Table 11 shows for selected vitamins cartels the changes in global market shares during the conspiracies of the 1990s. In only five of the 16 markets did the cartels experience significant erosion in the degree of control, namely, vitamins B1, B2, B6, B9, and C. In the case of vitamin B2, the cartel was unable to thwart the rise of the Archer Daniels Midland Company. ADM had purchased a plant and its fermentation technology from Coors brewing; this

[149] Spratling and Arp (2005) offer one of the most comprehensive overviews of cartel leniency programs. A radically revised version of the DOJ's Corporate Leniency Program was effective in late 1993. However, DOJ officials were still giving speeches about the new policy in 1995; moreover, details and important amendments to the Program were announced in 1998 and 1999 (*ibid.* note 11)

[150] Table 11 is based on sales shares. Because most of the fringe firms were expanding production capacities faster than sales, shares computed on the basis of capacities show larger percentage-point gains for fringe firms.

biotechnology proved to be more efficient than the cartel members' synthetic technology. In the other four markets, it was aggressive export expansion of Chinese producers that accounted entirely for the cartels' loss of market control. In the vitamin C market, the value of exports from China increased 250% from 1990 to 1995. In many of the vitamins markets the success of many producers was short-lived. For example, in 1995 there were 28 Chinese companies making vitamin C and at least eight making vitamin B1. By 2001, after prices returned to competitive levels, consolidation left only five vitamin C companies and only two vitamin B1 manufacturers in China (UKCC 2001: 10).[151]

Another common feature of these five product markets was the participation of Takeda or Daiichi in at least one of the industries; perhaps these companies were less committed to the cartel agreements and more troublesome about their assigned quotas. The sixth brief cartel, biotin, fell apart for other reasons.[152] All six of these cartels began in early 1991 and ended in either 1994 or 1995. The mean duration of the short-lived vitamins cartels (B1, B2, B6, B9, H, and C cartels) was 3.9 years.

Vitamin C was the largest of these six cartels. The other five were quite small. In terms of affected sales, the six short-lived conspiracies accounted for only 21% of the sales of all 16 cartels (Appendix Table1)

[151] Although far smaller in numbers the Chinese survivors retained substantial production shares of the global markets for vitamin C (25-26%) and B2 (one with 29% of the pharma-grade market, the other with 10% of the larger feed-grade market).

[152] The biotin (vitamin H) cartel was also short-lived (less than four years in North America), but entry by fringe firms does not explain this pattern. Rather the fact that it had five members may have led to its relatively early demise.

Table 11. Changes in Global Market Shares during the Conspiracies of the 1990s

Company	A	B1	B2	B6	B9 [a]	C	D3	H [b]	Caro-tinoids
					Percentage points				
Roche	-1	-4	-12	-7	-8	-11	-2	-2	-13
BASF	0	-1	-1			-1	+2	-4	+13
Rhone-Poulenc	0						0		
Takeda		-5	+5	-2	-5				
Eisai						-4			
Daiichi				-1					
E. Merck						-2		+6	
Solvay							-2		
Lonza								0	
Kongo					-3				
Sumitomo [c]					-7			+3	
Tanabe								-2	
Cartel total	0	-10	-8	-10	-20	-17	0	-1	0
China	0	+10	0	+10	+20	+17	0	-1	0
Other fringe	0	0	-8	0	0	0	0	0	0

Sources: Bernheim (2002a) and Appendix Tables 5 and 6. Firms and products not shown experienced virtually no changes in shares.
a) Better known as folic acid
b) Better known as biotin
c) Sumitomo's subsidiary Sumika sold folic acid.

The End of the Durable Cartels

All the other vitamins cartels endured for six to ten years in the 1990s.[153] Most of the cartels were operating smoothly up to the end, despite increasing signals to outsiders that collusion was afoot. According to one source, U.S. investigators first got wind of the vitamins cartel and Roche's role in it in late 1996 from sources at ADM cooperating with the DOJ in its investigation of the citric acid cartel. At that time ADM was making biotin (vitamin H) and was soon to enter production of vitamins E and C. Perhaps Barrie Cox had learned about the vitamin price fixing from one of his contacts at Hoffmann-La Roche.[154] Another possibility is that ADM had learned of rumors of price fixing when it studied the new vitamin markets it was entering. As a result of the tip, the FBI interviewed Dr. Kuno Sommer in March 1997 (Barboza 1999).

Dr. Kuno Sommer was at the time president of Roche's Vitamin and Fine Chemicals division.[155] Sommer had to agree to the interview because of Roche's promise to the DOJ to cooperate in the citric acid case. During the FBI interviews Sommer denied the existence of any

[153] The one exception is biotin, which lasted for slightly more than four years.
[154] Andreas Hauri was Roche's global sales manager for both vitamins and citric acid.
[155] This unit manufactures and sold flavors and fragrances, bu the majority of the Division's sales were vitamins and vitamin premixes.

vitamin cartel, and the DOJ apparently decided to wind down its investigation for the meanwhile. What the investigators did not know at the time is that Sommer had pre-arranged his denial with other conspiring company officers at Roche. Their agreement to deceive the FBI constitutes obstruction of justice, a very serious offense under U.S. law.

More evidence of illegal price fixing began to appear. In late 1997, a partner of the law firm Boies & Schiller with experience in representing class-action plaintiffs claims to have discovered evidence of vitamin price fixing in the course of preparing a patent-infringement suit. Soon after Roche dropped a counter-claim in the case, he began hearing many complaints from Roche customers. Vitamin buyers reported several instances of inexplicable behavior. Customers who habitually purchased from Roche would not be able to get price quotes from BASF or other suppliers, and vice versa. Buyers of vitamin C were threatened with unspecified retaliation should they try to resell purchased products. A manager of a small vitamin premix company in Little Rock, Arkansas quoted a BASF executive as threatening his company with the following words: “You need to remove yourself [from the premix business] or you’ll be forced out of the business” (Barboza 1999). The Little Rock company and many others did in fact fail.

In late 1997 or early 1998, lawyers working for Roche heard about allegations that some managers in the company were fixing vitamin prices (Barboza 1999). Apparently, they discovered some corroborating evidence because a top Roche official issued a directive specifically ordering that the conspiracy stop. This directive was defied. The only effect was to move the cartel’s meetings from hotels and other public places to the homes of the vitamins executives. This subterfuge extended the cartel’s life by another year.

In March 1998, Boies & Schiller filed a civil price-fixing suit in U.S. District Court in Dallas, Texas on behalf of several direct purchasers of bulk vitamins. The buyers were a mix of animal feed manufacturers and blenders of bulk vitamin premixes. Plaintiffs in civil suits against Roche and BASF alleged that predatory pricing forced many premix companies to fold; the vitamins sold to feed manufacturers as a premix were priced below cost at the same time bulk vitamins sold to premix companies were sold at monopoly prices. It would be more than one year before the government indicted Hoffmann-La Roche, BASF, and others for the same crimes.

Perhaps these and other allegations were forwarded to the DOJ because a grand jury was established in Dallas, Texas in November 1997 to investigate vitamin price fixing. The FBI interviewed officers of animal-feeds firms, but little progress was made for the first year. In the summer of 1998, one of the vitamin manufacturers, the Swiss firm Lonza, began to negotiate a guilty plea agreement with the DOJ. Although signed in secret in September, the size of Lonza’s fine shows that it could not provide much useful information about the “Roche Group” conspiracies.

On a somewhat separate track, the North American choline chloride cartel was derailed in June 1998. Perhaps because of customer complaints or an internal investigation, top executives of Bio-Products, Inc. got wind of the illegal collusion being carried out by Tom Stigler, vice president and general manager of Bio-Products feed ingredient group (Barnett 2005:8-15). Stigler was confronted by his supervisors who were previously unaware of the price-fixing conspiracy.[156] Stigler confessed his role and ceased contacts with his co-conspirators. Bio-Products immediately applied for and was granted amnesty by the DOJ. In return for immunity from prosecution for the company and its officers, Bio-Products cooperated by supplying information to federal prosecutors about the choline chloride cartel.[157] That summer, the company began competing for customers the old-fashioned way, by offering lower prices. On

[156] Stigler took elaborate precautions to mislead his company by, for example, filing fraudulent travel records when he traveled to cartel meetings.

[157] Six years later Stigler would testify in court against one of his fellow conspirators.

September 23, 1998 FBI agents raided the offices of DuCoa and Chinook and carted off incriminating documents. While that police action effectively ended the choline chloride cartel, the information delivered to the DOJ would have had little of value in cracking the other 15 vitamins cartels.

The DOJ's biggest break in its investigation came in January 1999. Following brief negotiations, the third largest vitamin manufacturer, Rhône-Poulenc, was admitted to the Department's leniency program. As the first of the conspirators to come forward and admit its culpability, Rhône-Poulenc probably met all the conditions for full amnesty. Conditional upon satisfactory cooperation with the DOJ's vitamin price-fixing probe, Rhône-Poulenc would receive a tangible benefit: no U.S. government fine would be levied on the company, and none of its officers were indicted. Although Rhône-Poulenc's compensation was substantial, the DOJ's demands were likewise. Rumor has it that Rhône-Poulenc's managers were required to attend a conspiracy meeting in February 1999 and tape record it. In effect, Rhône-Poulenc took up Mark Whitacre's mantle, becoming an FBI mole.

Whatever the evidence provided by Rhône-Poulenc, it must have been highly incriminating. Within two months both Roche and BASF had agreed to plead guilty and pay record-setting U.S. fines of $725 million. Within two years, 24 criminal convictions would be obtained. Rhône-Poulenc's motives were hardly pure. Not only did it save more than $100 million in U.S. fines, the company was now free to carry out its long-planned merger with Hoechst. In the end, it was the urge to merge that broke the vitamin cartel's cover.

EFFECTS OF THE VITAMINS CARTELS

Like many pharmaceutical products, the consuming public has a high regard for the benefits and efficacy of vitamins. There is something particularly reprehensible about price-fixing schemes that affect products destined for vulnerable populations. Children, pregnant or lactating mothers, the sick, and the elderly often need supplementary vitamins to achieve full health. These groups, as well as practically every household, ultimately paid the price of price fixing in vitamins. The purpose of this section is to document as precisely as possible the extent of these economic injuries.

Duration

Several factors explain cartel duration. Economic hypotheses on cartel duration have been offered by Posner (2001), Scherer and Ross (1990), Carlton and Perloff (2004), Martin (2002), Grout (2005), and Jacquemin and Slade (1989). Among the most consistent hypotheses are that duration is positively affected by high market concentration or the degree of cartel control of production, product homogeneity, barriers to entry, information asymmetries between cartel members and fringe producers, steady market growth, simple channels of distribution, a prior history of collusion, helpful trade associations, low fringe capacity, and credible cartel policies for punishing violators. Moreover, there are a few empirical studies of cartel duration (Levenstein and Suslow 2004, Zimmerman 2005). These studies have confirmed some of these hypotheses, namely, the positive effects of high cartel industry control, low buyer concentration (except for the single buyers in bid-rigging schemes), cultural homogeneity, existence of a trade association, the growth of antitrust amnesty programs, and the size of overcharges or monetary sanctions imposed.

In the vitamins industries several of these factors appear to explain differences between short-lived cartels like the water-soluble vitamins and long-lived conspiracies like vitamins A and E (see Box). The more durable cartels had higher degrees of supply control, many buyers, high barriers to entry into manufacturing, capacity constrained fringe producers, and membership drawn from at most two business cultures. Most of the short-lived cartels were threatened from the outside by fringe production, and this in turn instigated internal dissention.

Figures 4 and 5 display the price movements for vitamins B1 and C, which are exemplary of the more fragile conspiracies.[158] Annual transaction prices in the U.S. and European markets move closely together over time. Only rarely do the dollar-based prices in the two regions depart by more than 10%. It is a safe assumption that international geographic arbitrage would ensure that prices in other parts of the world would track closely the movements in U.S. and EU prices.[159] In both cases, prices rose and remained moderate high from 1985 to 1988; then, after dipping slightly, prices rose again for three to five years. When collusion stopped, prices crashed by 45 to 60% within three years, reaching levels lower than were ever observed in the 1980s.

[158] The prices shown are from the internal records of the major vitamins conspirators. They are compiled for the U.S. market by Bernheim (2002a) and for the EU by the European Commission (2003). Vitamins B2, B6, folic acid (B9), and biotin had similar price patterns.

[159] In importing countries the relevant comparable prices are f.o.b. border prices, not domestic prices that may be affected by import tariffs.

Collusion in the 1990s: The Long and Short of It

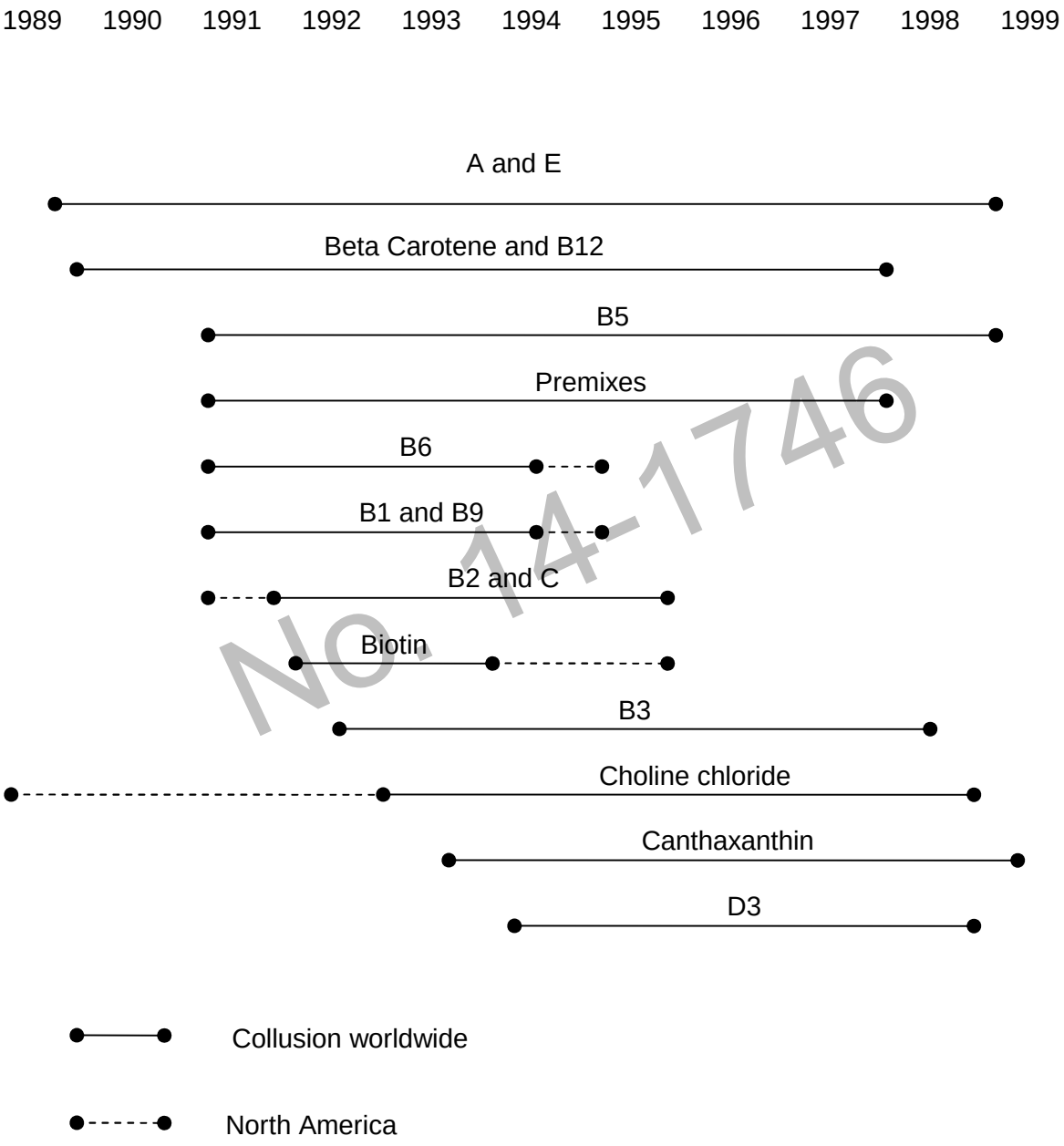
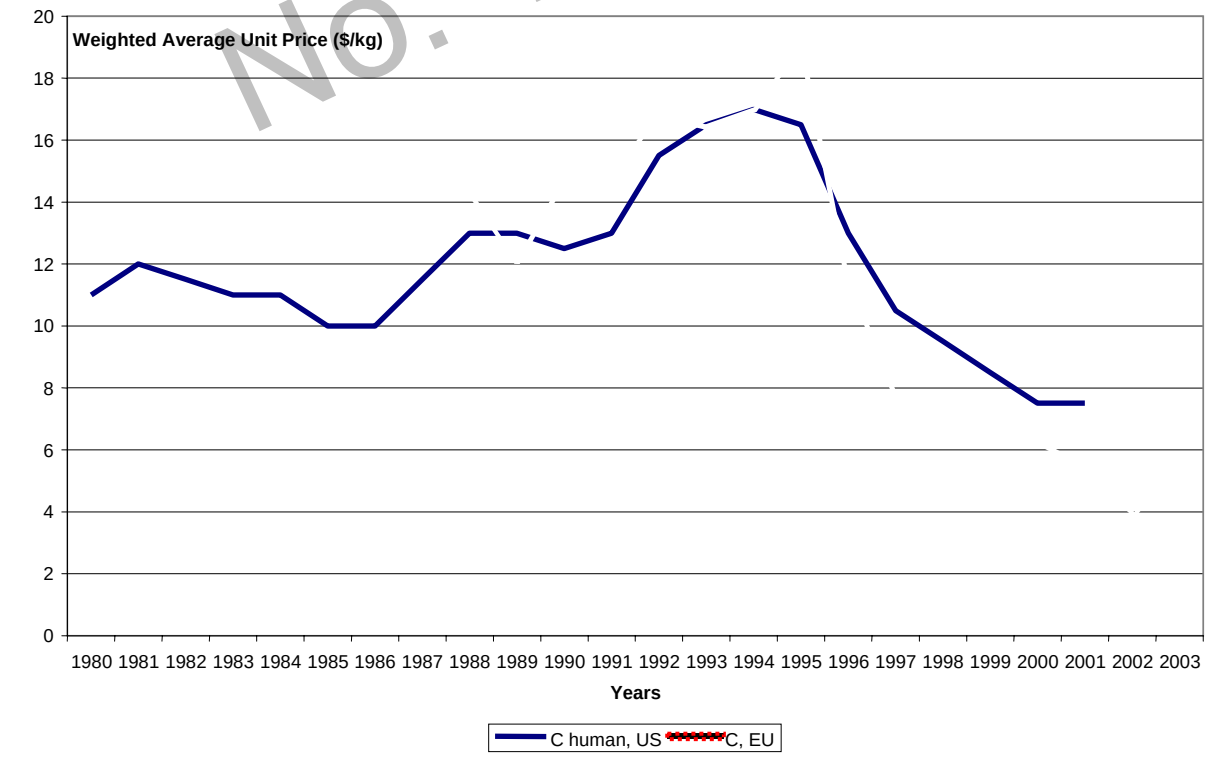


Figure 4. U.S. and EU Transactions Prices of Bulk Vitamin B1, Human Grade, Annual 1980-2003

Figure 5. U.S. and EU Transactions Prices of Bulk Vitamin C, Human Grade, Annual 1980-2003



Price Effects

Bulk vitamins are homogeneous products with highly inelastic demand. Given the high concentration of sales in the hands of the cartel and the cartel's elaborate methods for detecting cheating, the ability to raise buyer's prices would be expected to be very high. DOJ officials who had seen the U.S. transaction price data submitted by the vitamins cartel members were impressed with how cautious the sellers were in raising prices at the beginning of the conspiracy. Prices were increased slowly and in stages, rather than the sharp escalation seen in the lysine and citric acid cartels (Connor 2001).

By the time the cartels of the 1990s reached their peak pricing, U.S. transaction prices mostly were 20 to 70 percent higher than in the immediate pre-conspiracy period. In the case of the short-lived cartels like vitamins B1 and C, prices peaked at 20 to 40% above their 1989 levels (Figures 4 and 5). However, for the majority, more durable conspiracies peak prices were reached six to eight years after the pre-cartel year. These price increases typically were in the range of 50 to 90%. Figures 6 to 8 illustrate the transactions prices of three more disciplined and more durable vitamins cartels: vitamins E (human grade), A (feed grade), and B5 (human). Maximum U.S. prices were reached in 1997, and these apogees were 65 to 90% above the 1989-1990 starting points. EU prices traced similar, if slightly dampened paths.

Figuer 6. U.S. and EU Transactions Prices of Bulk Vitamin E, Human Grade, Annual 1980-2003

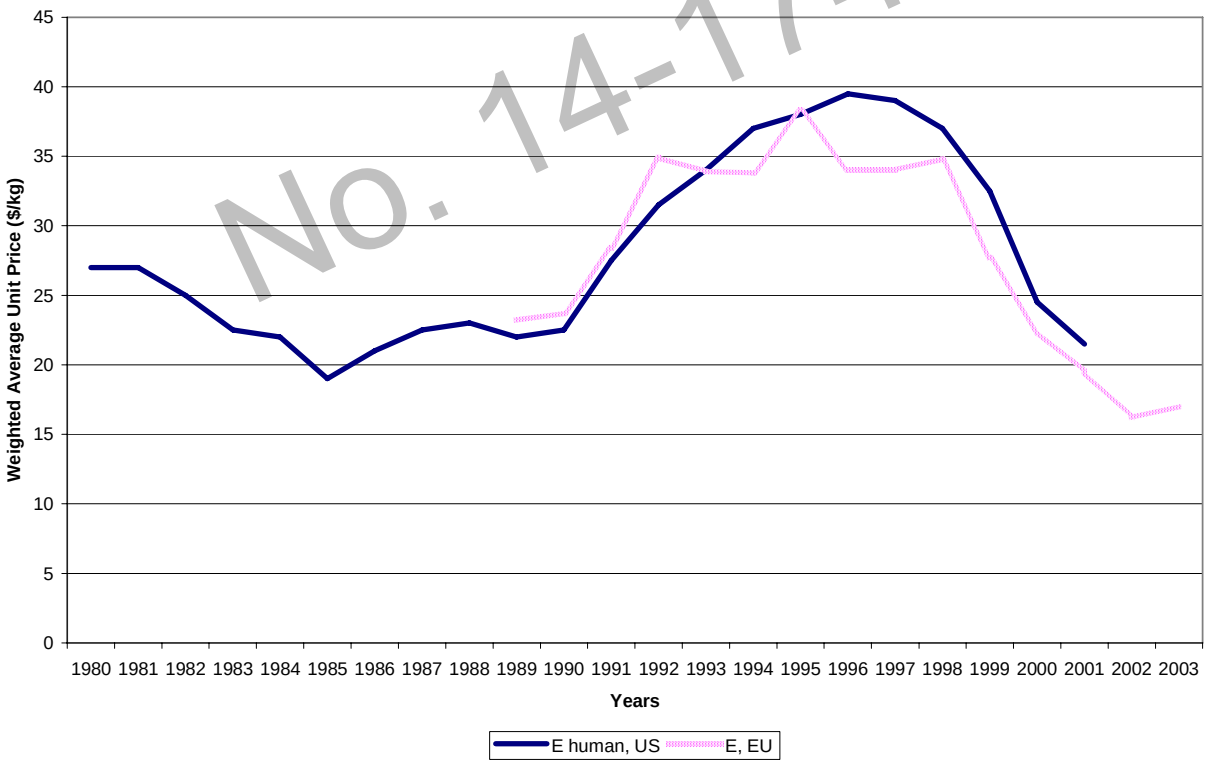
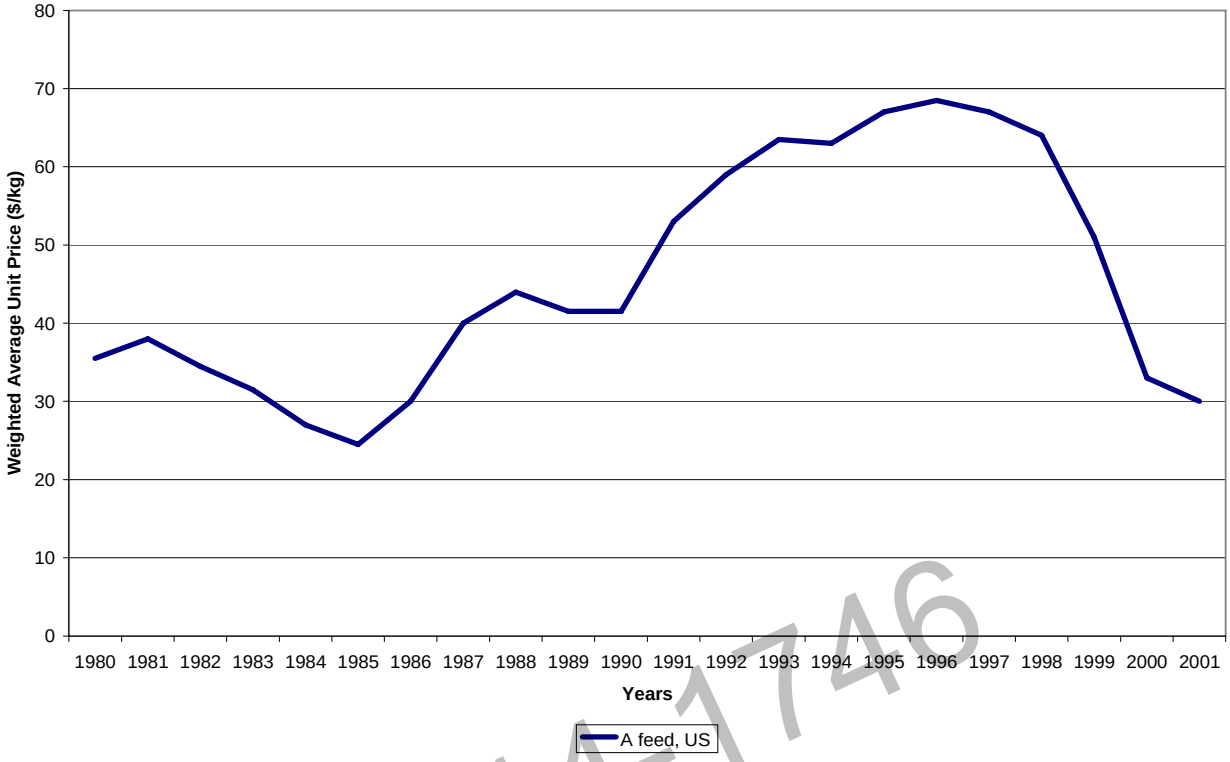


Figure 7. U.S. Transactions Prices of Bulk Vitamin A, Feed Grade, Annual 1980-2001



Figue 8. U.S. and EU Transactions Prices of Bulk Vitamin B5, Human Grade, Annual 1980-2001

Like an exciting roller-coaster, the decline in vitamin prices observed after the government announced the guilty pleas in May 1999 was much more precipitous than the earlier increases. An analyst at SRI Consulting, a company that follows the chemicals industries closely, stated that the vast majority of vitamins prices had collapsed by 50 percent within two months, causing sellers' margins to approach zero.[160] This suggests that the post-conspiracy period was far more competitive than the pre-conspiracy period. The major members of the convicted cartels may have been trying to repair bruised customer relations and retain their market shares the old-fashioned way – cutting prices to the bone.

There were just two exceptions to the roller-coaster price pattern in prices. Beta Carotene and the other carotinoids[161] were unusual among all the cartelized vitamins in that they were manufactured by a true duopoly, Hoffmann-La Roche and BASF. The two-firm structure persisted after formal collusion ceased at the end on 1998. The highly cooperative, indeed monopolistic behavior cemented during the lengthy collusive period seems to have continued after 1998, a result predicted for small-firm industries by dynamic game theories (Tirole 1990: 245-253). Lags in downward adjustment of prices after the end of formal collusion were characteristic of all the vitamins cartels, durable and fragile. Arriving at the low prices that signaled a new, more competitive equilibrium took from 12 to 36 months for all but the two carotenoid duopolies (Kovacic et al. 2006). The carotinoids were unique because there were no signs of a slackening of monopolistic pricing behavior a full three years after the cessation of collusive meetings (Figure 9). After 1998, the three largest manufacturers (Roche, BASF, and Rhone/Aventis) continued secretly to exchange sales data for the purposes of monitoring "the previously agreed market shares" and avoiding "price deterioration."[162]

For several reasons, the increase in U.S. market prices from the initiation of price fixing in 1990 or 1991 may not measure accurately the *effect of collusion* alone. This may be true even if the managers of Vitamins Inc. truly believed that their agreements were the primary cause of the rise in prices.

For example, the price changes just discussed were measured in U.S. dollars. Multinational companies generally seek to maximize the company's global profits.[163] Over time profits accumulating abroad are repatriated to the company's home country and converted into the home country's currency. Because the principal members of the vitamins cartels were based in Europe or Japan, they would want to set local prices from the point of view of their home-country's currency. Moreover, more than half of the bulk vitamins sold in the United States in the 1990s were imported from Europe, Japan, and China. Because the U.S. dollar strengthened against the home-country currencies of the cartel participants, higher vitamin prices observed in the U.S. market could be due to two independent causes: collusion and currency-rate changes. For example, if a cartelized U.S. vitamin price rose by 70 percent and if the product was imported from Switzerland, a rise in the value of the Swiss frank of 20 percent over the same period would imply that collusion was responsible for raising the U.S. price by only 42 percent.[164] An increase in Swiss manufacturing costs could further moderate the size of the collusive effect as measured by U.S. prices.

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[160] The annualized data shown in Figures 4 to 8 do not support quite so large a decline from 1999 to 2000, but such rates are noted by 2001 or 2002.

[161] There were three "other carotinoids." However, price data are available for only canthaxanthin, the largest of the three products. It is not clear if the two others were cartelized in the U.S. market.

[162] Partial quotations from deposition testimony of Dr. Thomas Wehlage, a BASF representative made on January 10, 2002 (Bernheim 2002a: footnote 139).

[163] In the simplest cases, a multinational's stockholders and its listing stock market will be located in the company's headquarters' country. For Roche that is Switzerland, and thus Roche would aim to maximize profits calculated in Swiss franks.

[164] This comment does not apply to the Chinese Yuan, which was tied to the U.S. dollar.

The vitamins defendants proffered three principal arguments to support their position that U.S. prices rose because of natural, competitive market forces.[165] The most frequent competitive explanation of ballooning prices in the 1990s was rising prices of raw materials, intermediate materials, transportation, or manufacturing expenses. In some cases the proximate causes of the putative cost increases were claimed to arise from government regulations concerning product quality or environmental standards. Second, the defendants argued that in the 1990s the U.S. dollar generally weakened against the Yen and most European currencies. Third, the vitamin manufacturers proposed that rapid increases in demand resulted in insufficient production capacity.

Bernheim (2002a: Chapter 9) demolishes these arguments by confronting them with market data and facts contained in the defendants internal records. First, variable costs did not vary significantly during the collusive periods for any of the vitamins.[166] Costs were generally flat or slightly declining.[167] More tellingly, variable costs were not relatively low in the years before or after the collusive periods. Second, the defendants' foreign-exchange arguments were not supported.[168] After adjusting for foreign-exchange movements, variable costs expressed in dollars were even more constant before, during, and after collusion than was the case before such adjustments.

Third, there is no relationship between surges in the quantity of vitamins demanded and increases in vitamin prices. The major increases in consumer demand were the result of publicity about the health benefits of mega doses of vitamins E, C and beta carotene. Annual increases in global consumption of these three vitamins reached 15 to 20%% in the early 1990s. While these rates of increase are quite high, similarly high increases in demand had occurred in the mid to late 1980s. Price increases from shifts in demand would only be observed if the demand shifts were unexpected. Moreover, when aggregated over species changes in the demand for animal-grade vitamins were exceedingly steady throughout the 1980s and 1990s.[169] Nor were there significant shifts in the ratio of human to animal uses of vitamins. What all these demand factors amount to is a highly predictable demand environment for bulk vitamins, a situation that lends itself to accurate planning for capacity expansions well in advance of needs. Shortages that drive up prices are unlikely to develop in such markets. In fact, the defendants' own estimates of global capacity utilization tended to decline during the collusive periods for the major vitamins.[170] Therefore, surges in demand were predictable, and changes in capacity constraints do not correlate with price changes in the 1990s.

[165] These explanations were contained in contemporaneous documents found in the defendants' files, in depositions given by managers, or in statements made to journalists writing in chemical-industry trade magazines (Bernheim 2002a: 122-124, 140, 145, and 150). Except for the exchange-rate explanation, these also apply to prices in the rest of the world.

[166] Vitamin B1 may be an exception. Given the oligopolistic market structure of the vitamins industries, one would expect to see pass-on rates of less than 100%, which would show up as greater variation in costs than in prices.

[167] Although irrelevant for price-change decisions, fixed costs also generally declined. Nor did prices or fixed costs rise when major companies exited.

[168] Two economic principles tend to suggest that fluctuations U.S.-dollar exchange rates have little explanatory power. First, it is generally accepted that the pass-through of changes in the prices of imported inputs to changes in domestic prices is generally around 50%. Second, many of the raw materials purchased for foreign production of vitamins were in fact denominated in U.S. dollars.

[169] The principal basis for estimating the demand for animal grades was changes in the slaughter rates for meat animals. There are notable production cycles for hogs and cattle, but these cycles were not positively correlated. Some species have experienced alterations in genetic types that could absorb high intensities of vitamins in feed rations, but such alterations were gradual.

[170] Capacity is an elusive concept. It depends on engineering estimates of maximum possible output, and assumptions about operating days of production per year, maintenance schedules, substitutability among plants for alternative outputs, and strategic decisions about optimal excess capacity. An interesting

The U.S. average price increases of the vitamin cartels are summarized in Table 12. The method of calculating the overcharges are predictions from richly specified econometric models that explains monthly variation in prices of 37 vitamin products from 1980 to 2001 (Bernheim 2002a: Chapter 10). The list of proxies for demand and supply shifters is quite extensive and tailored to the specific vitamin product. The model was generally fitted to prices prior to the conspiracy period and for the periods one year after the conspiracy periods.[171] Then the estimated parameters for these relatively competitive periods were used to predict the conspiracy-period "benchmark prices" -- the prices that would that have been observed absent explicitly collusive conduct. The difference between the benchmark price and the actual price is the estimated cartel overcharge for each month. Table 12 shows the mean price increase for all months of each vitamin's conspiracy period.

Table 12. U.S. Vitamin Price Mark-Ups Based on Econometric Modeling

Product	Plea Period [a]	Extended Conspiracy Period [b]
	Percent	
Vitamin E	63.2	61.3
Vitamin A	48.8	56.7
Vitamin C [c]	31.0	35.3
Vitamin B1 [c]	22.1	23.8
Vitamin B2 [c]	29.9	37.6
Vitamin B3	18.5	21.2
Vitamin B4	50.7	50.8
Vitamin B5	45.0	61.6
Vitamin B6 [c]	31.5	17.5
Folic Acid (B9) [c]	28.6	28.7
Vitamin B12	80.4	95.7
Vitamin D3	15.6	22.7
Beta carotene	44.4	60.0
Canthaxanthin	24.2	33.9
Biotin (vitamin H) [c]	21.3	39.1
Vitamin premixes	41.9	45.6
Total	43.7	48.2

Source: Bernheim (2002a: vi, 8-9), converted from the given Lerner Indices.
a) Generally guilty pleas in the U.S. or elsewhere from 1990 to about 2001 or shorter.
b) Includes the plea periods plus several periods during 1985-1989.
c) One of the six short-lived cartels.

comment by a deposed Hoffmann-La Roche expert is: "…[A]ctual output is a fact. Capacity is an opinion." (Bernheim 2002a: 145). Roche's own estimates of global capacity utilization for vitamins A, E, and C tended to average 75 to 80% in the 1990s (*ibid.* 148-150).

[171] Bernheim (2002a) does not use post-cartel data for those industries that are duopolies because the post-cartel tacit pricing conduct in those markets seemed to be as profitable as that during the conspiracy period.

Price increases in the 1990s averaged 44% and varied from 16 to 80% across the 16 vitamins cartels. Many factors explain the height of the overcharges, duration being one. There is a difference between the six cartels that were under stress and fell apart fairly quickly (about four years) and the ten more durable agreements. Duration does not only result from a failure of fringe producers to mount serious challenges to cartel control but also seems to signal the cohesiveness and discipline among the members of some of the cartels. On the one hand, the six more fragile coalitions achieved mean overcharges of only 27.4% during the plea-periods of the 1990s; for the extended, dual-episode conspiracy period the mean was a similarly below-average 30.3% (Table 12). On the other hand, the ten long-lasting cartels achieved significantly higher mean overcharges of 43.3% and 51.0% for the plea-period and extended-period, respectively. The greater price effects of the durable cartels are important, because they accounted for 79% of plea-period affected sales.

There were 14 cartels alleged to have had collusive periods in the late 1980s. Except for vitamins E and B6, the overcharge rates in the late 1980s were higher than in the 1990s. Thus, the 16-product average price effect that includes the 14 extended conspiracy periods (roughly mid 1985 to the beginning of1999) was one-tenth higher: 48.2%.

A second method produces roughly similar estimates of the cartel price effects during the plea period of the 1990s (Table 12A). This method is called the cost-based or constant-margin approach. To obtain benchmark prices, the analyst assumes that the ratio between price and variable costs during non-conspiracy periods would stay the same during the cartel period (absent explicit collusion) as they were before and after the conspiracy. Costs are taken from the internal production records of the defendants; if members of a cartel fail to minimize costs, this approach would tend to produce negatively biased estimates.[172] Except in those vitamin industries for which defendants did not provide cost information, the constant-margin analysis generally produces reasonable price-cost patterns in the post-cartel periods. That is, when costs fall, so do prices, and prices usually stop falling when they approach costs.

In general, the constant-margin approach produces estimates that are quite close to the econometric-model estimates. The mean cartel mark-up for the plea periods of the 1990s is 42%, and most of the individual vitamins are within a few percentage points of the econometric results. [173] As before, the constant-margin approach reveals that the six less durable cartels had mean overcharges that were less than half the overall average.

[172] There is a large economic literature, mostly theoretical, that supports X-inefficiency in collusive industries.

[173] Except for vitamin D3 and premixes, the simple correlation of the plea-period overcharges is strongly positive (0.93).

Table 12A. U.S. Vitamin Overcharges Based on Constant-Margin Analysis

Product	Plea Period [a]	Extended Conspiracy Period [b]
	Percent	
Vitamin E	65.0	46.8
Vitamin A	42.9	47.3
Vitamin C [c]	27.4	21.7
Vitamin B1 [c]	11.4	12.6
Vitamin B2 [c]	28.4	19.1
Vitamin B3	16.1	16.1
Vitamin B4	--	--
Vitamin B5	59.7	78.6
Vitamin B6 [c]	20.6	7.2
Folic Acid (B9) [c]	19.2	19.2
Vitamin B12	--	--
Vitamin D3	48.6	58.2
Beta carotene	40.1	60.5
Canthaxanthin	24.8	23.9
Biotin (vitamin H) [c]	4.8	9.5
Premix discount	5.7	--
Total	42.3	35.5

Source: Bernheim (2002a: 250, 295), converted from the given Lerner Indices. Bernheim (2002a: 207-244) calculates variable costs for each vitamin on a 100%-pure, worldwide basis. This method assumes that the but-for gross margin (price less variable costs) remains constant during the conspiracy.

a) Generally guilty pleas in the U.S. or elsewhere from 1990 to early 1999 or shorter.

b) Includes the plea periods plus several periods during 1985-1989.

c) One of the six short-lived cartels.

A third method for calculating overcharges is the simplest. It is called the before-and-after method. A straight line is drawn between the price in the month before the first collusive price increase is announced and the price 12 months after collusion ceases. The sum of vertical difference between the actual market prices and this line is the overcharge. The results of this analysis are shown in Table 12B.

Normally, the before-and-after method is of suspect accuracy because it fails to take account of changes in costs of production and demand shocks. Also, the choice of the end points of the line is a matter of judgment; generally, the beginning point could be set a year or two before collusion and the end point two or three years after collusion. However, because supply and demand conditions were so steady, the results of this before-and-after analysis appear to be quite similar to the econometric estimates for most products. The mean price effect in the 1990s is 48% and most individual estimates are within a few percentage points of the

econometric computations in Table 12.[174] The mean of the overcharges for the six short-lived cartels is much lower than the all-products average.

Table 12B. U.S. Vitamin Price Effects Based on the Straight-Line Before-and-After Method

Product	Plea Period [a]	Extended Conspiracy Period [b]
	Percent	
Vitamin E	67.2	65.6
Vitamin A	56.0	63.4
Vitamin C [c]	29.9	29.9
Vitamin B1 [c]	27.6	38.7
Vitamin B2 [c]	37.0	40.7
Vitamin B3	22.3	12.9
Vitamin B4	73.6	--
Vitamin B5	34.1	40.1
Vitamin B6 [c]	44.7	36.8
Folic Acid (B9) [c]	14.3	10.6
Vitamin B12	65.8	--
Vitamin D3	15.2	20.8
Beta carotene	40.3	59.2
Canthaxanthin	23.0	29.7
Biotin (vitamin H) [c]	13.0	20.6
Vitamin premixes	13.3	--
Total	47.9	45.4

Source: Bernheim (2002a: 250, 295), converted from the given Lerner Indices.
a) Generally guilty pleas in the U.S. or elsewhere from 1990 to early 1999 or shorter.
b) Includes the plea periods plus several periods during 1985-1989.
c) One of the six short-lived cartels.

The before-and-after method can be applied to price data taken from public sources (Table 12C). These estimates were prepared for 12 products in late 2001 from data on U.S. list prices or import prices. List prices are derived from announcements in *Chemical Market Report,* the chemical industry's main source of trade news. International trade data provide a fairly good proxy for U.S. transaction prices for vitamins B3 and B4.[175] In most cases only pre-cartel but-for prices are available.

[174] Bernheim (2002a:250-251) judges that the before-and-after method produces superior and more conservative estimates for beta carotene and the carotenoids because of spurious correlations in the data caused by strong pre-cartel and post-cartel trends in prices. The simple correlation between the plea-era overcharges for the 16 products is positive and large (0.80).

[175] Import prices include freight charges to the port of import, but do not include delivery costs to U.S. customers. Lonza was a major importer of niacin into the United Sates. Chinook imported a large share of national supply of choline chloride. Although illegal, Lonza or Chinook could have misreported the value of their U.S. imports, especially those to its own U.S. sales branch. Low U.S. tariffs make this scenario unlikely.

Book prices are crude substitutes for transaction prices reported by sellers or buyers. Generally, when a cartel is formed transactions prices will tend to respond proportionally to but greater than list prices (Connor 2001). That is, as industry pricing discipline rises during a cartel, the gap between list and actual prices narrows, partly because overt collusion eliminates discounts and rebates. Nevertheless, such surrogates may be the only sources of price data in the immediate period after a cartel is unmasked. Thus, it is of some interest to examine whether preliminary estimates are comparable to more polished numbers in Table 12B that have the benefit of time, detailed analysis, and access to true transaction-price data.

The public-data estimates of average conspiracy-period mark-ups in Table 12C have a simple mean of about 31%. As expected, list-price changes are lower than the transaction-price changes shown in table 12B. Also as expected, the price increases calculated from the two data series positively correlated (r = 0.74). On average the pairs of estimates are very close for the seven more durable cartels the mean ratio is 0.99), but the public-data overcharges are underestimated by about 40% for the five short-lived cartels. What this pattern of list-price changes seems to indicate is the cartelists were overly pessimistic their abilities to raise prices when the collusion proved to be fragile. On the other hand, list price announcements were realistic predictions of actual price effects for the cartels that lasted a decade or so. Finally, these comparisons suggest that estimates prepared from list prices will tend to be accurate for durable cartels but severely underestimated for short-lived ones.

Table 12C. U.S. Price Effects Based on Before-and-After Analysis of Public Price Data

Product	Types of Prices	Price Increases [a]			
		Average During Conspiracy		Maximum During Conspiracy	
		Mark-up	Margin	Mark-up	Margin
		Percent			
Long Lasting Cartels:					
Vitamin A	List & spot	60-70	25-30	80	45
Vitamin E	List & spot	55-65	30-40	90	95
Vitamin D	List & spot	30-35	20-25	45	30
Vitamin B3	Transaction	13-30	15-35	40-79	37-70
Vitamin B5	List & spot	35-45	20-30	60	38
Vitamin B12	List & spot	40-50	30-35	78	42
Vitamin B4	Transaction	35-50	25-30	60-100	38-50
Shorter Cartels:					
Vitamin C	List & spot	15-20	10-20	28	25
Vitamin B1	List & spot	8-10	8-12	12	36
Vitamin B2	List & spot	8-18	10-20	34	25
Vitamin B6	List & spot	4-30	5-40	15-50	13-44
Folic acid	List & spot	15-20	20-25	38	28

Source: Connor (2001: Chapter 12).

[a] The margins are the average price during conspiracy less the pre-conspiracy price (or in the case of vitamins B1, B4, and B6 post-conspiracy also) divided by the selling price. Mark-ups take the same numerator and divide it by the but-for price.

The only reliable transaction prices for the EU are annual 1988-1999 data shown in the European Commission decision (EC 2003). These price series are shorter than those available for the United States, but for most vitamins the U.S. and EU prices track closely together (see Figures 4 to 8). Table 13 summarizes the price effects for 12 of the bulk vitamins based on the before-and-after method. Price increases are quite sensitive to the choice of benchmark years. When the benchmark is price before or in the first year of collusion, the cartel mark-ups are generally not too dissimilar. However, the collapse in prices after collusion stopped in Europe was more drastic than in the U.S. market. Therefore, benchmarks derived from post-cartel prices produce larger overcharge estimates than pre-cartel prices, and the estimates rise with the distance from the terminal year.

Table 13. EU Vitamin Price Effects, 1988-1999 Transactions Prices

Product Market	But-For Price				
	Years Before Cartel	1st Year of Cartel	Years after Cartel		
			First	Second	Third
			Percent		
Vitamin A	24.7	25.4	--	--	--
Vitamin E	30.5	47.4	--	--	--
Vitamin C	21.7	8.9	40.1	105.1	105.1
Vitamin B1	5.6	3.8	28.0	67.9	64.1
Vitamin B2	24.6	23.9	5.9	79.0	80.1
Vitamin B5	45.0	33.9	--	--	--
Vitamin B6	13.6	36.3	39.7	84.2	89.3
Vitamin B9	0	--	--	--	56.6
Vitamin D3	--	11.0	--	--	--
Beta carotene	--	--	0	0	--
Canthaxanthin	--	1.2	--	--	--
Biotin (vitamin H)	0	0	12.5	42.0	96.4

-- = Not available
Source: Appendix Tables 3 and 4.
Note: Simple average of annual EU transaction prices in euros during the collusive period divided by the but-for price.

The last source of information about price effects is formal empirical studies by academic economists and economic historians. Suslow and Levenstein (2002) cited North American overcharge figures of 20% and 30% in their survey of modern cartels. A sophisticated econometric model of world trade in bulk vitamins also yielded similar conclusions about collusive price effects (Clarke and Evenett 2002). What is of special interest about this study is that the authors are able to calculate overcharges for the 19 countries outside the EU and North America with the strictest antitrust laws separately from those countries with weak antitrust enforcement; the former had overcharges averaging 13% while the latter incurred a 33% overcharge. Therefore, it seems likely that monopoly profit rates from collusion in the rest of the world were higher than in the United States, Canada and the EU. Finally, a dynamic simulation model fitted to parameters drawn from the vitamin C industry predicted the U.S. price during

fully collusive and non-collusive regimes (de Roos 2001). The main result is that U.S. vitamin C prices were 22% to 26% higher during the cartel period, which is quite remarkable given that this is was one of the weakest and most fragile of the vitamins cartels.[176] This finding is comparable to the overcharge seen in Table 12.

Profits

Price increases of the type just described were bound to increase seller profits to extraordinary levels. What profit rates were prior to collusion is impossible to learn with any precision because the cartel members did not report operating profits separately for their vitamins lines of business. Vitamins were usually part of some broader corporate division called specialty or fine chemicals. Whole-company profits are not particularly useful indicators because they were affected by the high profits normally found in pharmaceutical businesses or the lower profit rates associated with other bulk organic chemicals. Roughly speaking, for the largest publicly listed chemical firms operating profits on vitamins in the 1980s were in the range of 5 to 15 percent of sales (Connor 2000: Appendix F).[177] Production costs were generally stable before, during ad after the cartel periods of the 1990s. Because the additional management costs of operating "Vitamins, Inc." were small relative to the increase in sales, during the long-lasting cartels' most effective years vitamin profit rates will have risen to two to six times non-conspiracy rates.

During fiscal years 2000 to 2005 monopoly profits will have disappeared, but these years are not useful benchmarks because of the impacts of large fines and civil settlements (discussed below) will distort profit statements. For example, stock analysts have spent considerable effort in calculating the effects of fines on the earnings of Hoffmann-La Roche. When the company paid a U.S. fine of $500 million, the fine represented 17 percent of the company's FY 1998 net income from all lines of business and 20 percent of its sales of vitamins and fine chemicals division. It is conceivable that this fine alone wiped out Roche's total profits from vitamins for 1998, as Roche's CEO claimed in a 1999 interview. However, it is well to recall that Roche's illegal activities generated excess profits for *nine to 15* years, not just one or two.

Customer Overcharges

Profits generated by price fixing are a transfer of income from customers to the stockholders of the companies in the cartel. With no available substitutes, vitamin buyers had no choice but to continue making purchases at the cartel-inflated prices. The amount of this overpayment is called the customer overcharge. The size of the vitamin overcharges can be vitally important information for assessing felony fines in the United States and for judging the adequacy of civil antitrust settlements.

Overcharges are estimated as a routine matter by economists assisting prosecutors at the antitrust agencies as they weigh the seriousness of price-fixing charges, which concessions to offer to defendants in order to extract a guilty-plea agreement, and the size of fines or prison sentences to seek from the courts. During the investigation phase, prosecutors will often seize

[176] The study's author is reluctant to apply his model for the purpose of deriving a cartel overcharge. In a personal communication from Dr. de Roos, the method I used to derive an overcharge he describes as "…a comparison of two counterfactuals, i.e., the difference between a world described by my model with collusion, and a world described by my model without collusion."

[177] Because there is some evidence of collusion in the Roche cartels during 1985 -1988, returns in the early 1980s or 1989-1990 are the best indicators of normal profits.

documents that can be used to calculate overcharges; or later during plea bargaining defendants will often volunteer useful market data to prosecutors. Calculating the overcharge requires knowledge about the prices actually charged, the volume purchased from the defendants during the conspiracy period, and the price that would have reigned in the market absent collusion.[178]

The estimated size of a cartel's overcharge will have a strong influence on the prosecutor's starting point and stubbornness in negotiating a plea bargain. U.S. fines that are determined under the U.S. Sentencing Guidelines require the government to calculate and reveal the "base fine," which is 20% of affected sales, and adjustments to the base fine with culpability multipliers. The recommended fines for corporations typically range from 30 to 80% of the company's U.S. sales during the conspiracy. If the Guidelines result in a fine above the statutory limit ($10 million per company during 1990-2004), the fine may approach double the defendants' price-fixing overcharges under an alternative sentencing provision. The latter method of assessing a fine has become more common since about 2000.

Overcharges are central to both parties in civil antitrust suits, which are common in the United States and Canada and permitted but uncommon in other countries. Were a case to go to court, lawyers representing plaintiffs must present fair and reasonable claims of economic injuries in private suits. Lawyers representing defendants often have their own experts prepare alternative estimates. Unless the experts testify at trial, these economic analyses are rarely made public.[179] Defendants' and plaintiffs' overcharge estimates help determine the decision of whether to go to trial or how high an offer must be made to settle a treble-damages case. If settlement negotiations are protracted, plaintiffs' counsel sometimes make public statements about their client's injuries. Some exaggerate the seriousness of their clients' case by making various assumptions that lead to generous estimates of the overcharges, though this is not always the case.[180]

During the discovery phase of a private suit, defendants will be asked by plaintiffs to make available the prices actually charged, the volumes sold, market shares, customer lists, production and marketing costs, inventories, plant capacities and output, and internal strategic planning documents for periods before, during, and after the alleged conspiracy. Usually buyers also assemble accounting data on transaction prices and quantities purchased in the appropriate market period. Experts collect additional information from government reports, professional market studies, company financial reports, and trade magazines. Occasionally, the appropriate dates of the affected period are a matter of contention between plaintiffs and defendants, though a prior criminal conviction usually provides *prima facie* evidence on the conspiracy dates. Lags in implementing a price agreement typically delay the full effects on market prices in the first few months of a conspiracy. However, price lags following the formal termination of a conspiracy will also generate overcharges for a year or two. Defendants rarely wish to acknowledge responsibility for these carry-over effects. Most of the disagreement between plaintiffs and defendants will focus on the but-for price. Alternative methods of

[178] In those vitamin markets where fringe production existed, purchases from non-participants can also harm buyers because of umbrella pricing effects. Such sales reach 40% of the market in the last years of a few of the short-lived cartels. Even if fringe firms were aggressively seeking increases in their market shares, their prices were somewhat elevated above competitive levels. Under U.S. law such purchases are not compensable harms because the fringe firms were not explicitly parties to the cartel, but as a matter of economic welfare theory these buyers do sustain losses.

[179] Expert reports are typically kept under court seal perpetually, but in some cases the analyses are rewritten and published by the authors.

[180] Obfuscation can take the form of citing a briefly attained peak price increase, expansive product market definitions, the most favorable alternative but-for price, or durations that exceed plea periods and may be hard to prove in court. Less frequently defense counsel offer contradictory assessments.

economic analysis can be used to arrive at the but-for price, several of which require information that defendants will be reluctant to provide to plaintiffs.

Pronouncements by public prosecutors about the economic injuries spawned by a cartel are unusual or vague. On May 20, 1999, the U.S. DOJ announced the guilty pleas it had obtained from the three leading price fixers, Roche, BASF, and Rhône-Poulenc. Joel Klein, head of the DOJ's Antitrust Division, was asked how large the U.S. overcharges were on vitamins, but this question only elicited the vague response that they were "hundreds of millions of dollars." At the sentencing hearing in federal court in Dallas, Texas the same day, the DOJ was required to be more precise when it explained the basis for its proposed fines on Roche and BASF. The government's indictments specified price fixing on seven vitamin products.[181] With information on Roche's U.S. market shares for these vitamins during the conspiracy period and the sales of other vitamin products for which guilty pleas were later made, it is possible to infer the DOJ's assumption about Roche's overcharges. The total U.S. vitamins overcharges implied by Roche's fine are estimated to be $850 to $1,350 million. As the affected sales during the conspiracy claimed by the DOJ were $5 to $6 billion, the implicit percentage overcharge on bulk vitamin purchases is15 to 25%.

The size of the vitamin overcharges was a major issue during settlement talks between the Big Six defendants and private plaintiffs. In November 1999, these defendants offered to pay members of the federal class $1.17 billion to settle the treble-damages suit brought as a federal class action. There were some differences of opinion between the federal class counsel, who ended up representing mostly smaller claimants, and attorneys for the larger buyers in the class. The first group of lawyers consistently represented the settlement as a generous one. Robert Silver of the lead counsel firm Boies & Schiller opined that the recovery amounted to about 20 percent of U.S. purchases of vitamins during the affected periods. He stated that the $1.17 billion "somewhat exceeds" the overcharges paid by direct buyers on roughly $5.5 billion of vitamin purchases. However, Kenneth Adams of Dickstein Shapiro, who represented most of the larger buyers of vitamins, opined that the vitamins overcharges were considerably larger. His economic experts were working with a somewhat larger affected sales figure of about $7 billion. Adams asserted that the average percentage overcharge was 33 percent on the seven products sold by the Big Six defendants, or $2.3 billion. Extrapolating plaintiffs' counsel estimates to defendants beyond the Big Six (which accounted for 86 percent of sales) and beyond the seven products, the total U.S. overcharges amount to $1.6 billion (Silver's estimate) or $3.1 billion (Adams' estimate). In sum, the government's and the plaintiffs' estimates of U.S. overcharges fall within the range of 15 to 33 percent of affected sales.

More detailed calculations of U.S, Canadian, European, and world-wide overcharges are given for the cartels of the 1990s in Table 14. For all 16 vitamins products, the global total is about $7.6 billion. The overcharges were allocated geographically roughly in proportion to affected sales (compare Table 9). Buyers in North America paid 33% of the global price of price fixing, Europeans 37%, and the rest of the world 31%. Nearly half of the overcharges are accounted for by two products – vitamin E and premixes – and vitamins A and C for another quarter of the total.

[181] The products were vitamins A, E, C, B2, B5, beta carotene, and premixes. The conspiracies began in January 1990 or January 1991 and mostly ended around December 1998, except for C and B2, which ended in late 1995.

Table 14. Global Overcharges by the Vitamins Cartels, 1990-1999

Product	United States [a]	Canada [b]	Western Europe [c]	Other [d]	World [f]
	Million current U.S. dollars				
Beta carotene	120	7.4	175	74	376
Canthaxanthin	22.5	0.2	95	245	363
Biotin (H)	25	0.4	42.5	38	115
Choline chloride (B4)	158	13.5	137.0	185	493.5
Folic acid (B9)	2.6	0.4	12.5	1.0	16.5
Vitamin A	270	19.0	403	232	924
Vitamin B1	9.1	1.3	6.6	12	29
Vitamin B2	31.7	2.5	63	28	125
Vitamin B3	41.7	1.3	39	41	123
Vitamin B5	57	3.4	82	32	174
Vitamin B6	13	3.6	31	55	103
Vitamin B12	50	0.9	67	109	227
Vitamin C	242	17.0	290	413	962
Vitamin D3	9.7	0.7	11	10	31.4
Vitamin E	641	43.0	1090	421	2195
Premixes	602	51.3	774	866	2293
Total 16 products	2295	166.0	3318	2771	8549

a) From Appendix Table 13; includes umbrella effects. Revised 3/08.
b) Assumed same overcharge rates as in the United States.
c) Based on before-and-after benchmark prices shown in the annex of the EC decision, where available. Otherwise, used U.S. rates.
d) Clarke and Evenett (2001) found that vitamin imports by countries with weak antitrust laws were 50% higher than North America and the EU. To be conservative, assumed rates 20% higher than the U.S. and EU average (partly because China was immune to cartel effects for some of the B vitamins).
e) Estimated by author; highly uncertain.
f) Sum of the other columns.

Table 14A. Global Overcharges by the Vitamins Cartels, Late 1980s					
Product	United States	Canada	Western Europe	Other	World
			Million current U.S. dollars		
Beta carotene	5.2	0.3	7.6	2.6	15.8
Canthaxanthin	20.9	0.2	88.2	109.0	298.3
Biotin (H)	44.3	0.6	39.4	63.4	147.7
Choline chloride (B4)	0	0	0	0	0
Folic acid (B9)	0	0	0	0	0
Vitamin A	42.1	3.0	78.1	33.5	157.0
Vitamin B1	18.2	2.3	24.3	18.8	56.6
Vitamin B2	10.6	0.9	18.1	7.2	36.7
Vitamin B3	0	0	0	0	0
Vitamin B5	47.6	2.9	79.7	18.6	148.8
Vitamin B6	7.3	2.0	9.9	13.9	33.1
Vitamin B12	0	0	0	0	0
Vitamin C	254.7	18.0	286.2	45.3	909.6
Vitamin D3	3.1	0.2	4.2	2.8	10.3
Vitamin E	57.4	3.8	75.4	27.4	164.0
Premixes	170.8	14.6	219.8	204.8	610.0
Total 16 products	650.7	47.0	887.9	705.4	2291.2
Source: Bernstein (2002a: iii-9) and Appendix Table 1A.					

Table 14A repeats the overcharge calculations for the 12 shorter cartels that operated in the late 1980s. Total overcharges in nominal U.S. dollars were $2.3 billion, of which 30% was imposed on North American buyers, 39% on Europeans, and 31% the rest of the world. Two-thirds of the overcharges were derived from the vitamin C and premix conspiracies. Table 14B converts the overcharges from nominal currency (in the year the fines were imposed) to a common year, 2005. Even though inflation was fairly low from 1990 to 2005, this adjustment makes quite a difference. Measured in today's dollars, the damages from the vitamins cartels of the 1990s amounts to $11.5 billion – a figure 50% higher than the "old dollars" in Table 14.

Table 15 summarizes the overcharges for 16 products and four geographic regions relative to a conventional metric – affected commerce. As can be seen, econometric estimates of the U.S. overcharge rates from Table 12 are used not only for the United States but also for Canada and some of the EU cells. For ten of the vitamins, EU data provide adequate before- and after estimates (taken from Table 13). Lacking sufficient price data for six of the EU cartels, the U.S. estimates were substituted. Rest-of-the-world estimates are derived from a combination of the U.S. and EU overcharges. These methods are justified because of geographic arbitrage in an open trading environment.

Table 14B. Real Global Overcharges by the Vitamins Cartels, 1990-1999

Product	United States [a]	Canada [b]	Western Europe [c]	Other [d]	World [f]
	2005 U.S. dollars				
Beta carotene	160.6274	11.51163	284.9875	82.16095	539.2875
Canthaxanthin	30.11763	2.007842	153.8285	274.6201	460.5741
Biotin (H)	30.37667	3.206407	39.86509	44.99704	118.4452
Choline chloride (B4)	380.3922	30.8407	350.9996	267.614	1029.846
Folic acid (B9)	3.159174	0.577367	8.891455	2.131439	14.75943
Vitamin A	398.3374	29.94907	672.8273	245.9954	1389.761
Vitamin B1	11.05711	1.501155	7.621247	14.20959	34.3891
Vitamin B2	51.86621	4.090395	96.98315	28.10304	181.0428
Vitamin B3	61.521	4.351706	43.14159	45.76659	154.7809
Vitamin B5	113.6555	6.343892	164.1913	29.74828	319.0969
Vitamin B6	15.79587	4.157044	25.40416	39.07638	84.43345
Vitamin B12	60.75334	2.315738	54.27252	110.1243	227.4659
Vitamin C	431.0836	30.28273	497.7749	435.7608	1555.675
Vitamin D3	11.188	0.769231	14.4113	10.80473	37.17326
Vitamin E	947.1579	67.86489	1283.191	385.5835	2750.651
Premixes	888.1449	59.01295	856.1947	813.5011	2616.854
Total 16 products	3595.234	258.7828	4554.585	3105.634	11514.24

a) From Table 14; includes umbrella effects. To allow for the opportunity cost of capital, adjusted by the U.S. prime rate of interest plus 1% from the midpoint of the conspiracy to the year the cartel was fined by each jurisdiction; then from the latter year, the figure is raised to $2005 using the producer price index of the appropriate region.
b) Assumed same overcharge rates as in the United States.
c) Based on before-and-after benchmark prices shown in the annex of the EC decision, where available. Otherwise, used U.S. rates.
d) Clarke and Evenett (2001) found that vitamin imports by countries with weak antitrust laws were 50% higher than North America and the EU. To be conservative, assumed rates 20% higher than the U.S. and EU average (partly because China was immune to cartel effects for some of the B vitamins).
e) Estimated by author; highly uncertain.
f) Sum of the other columns.

Table 15. Global Overcharges Relative to Affected Commerce, 1990-1999					
Product Market	United States	Canada	Europe	Rest of the World [a]	World [b]
			Percent		
Beta carotene	30.61	30.83	30.65	36.82	31.68
Canthaxanthin	19.4	20.0	19.39	23.33	21.89
Biotin (H)	17.36	25.0	33.2	19.2	17.3
Choline chloride (B4)	29.87	30.75	39.9	33.64	33.66
Folic acid (B9)	22.61	20.0	64.1	20.0	43.42
Vitamin A	32.77	32.76	26.5	35.64	30.26
Vitamin B1	18.2	18.57	6.37	15.19	12.14
Vitamin B2	22.97	22.73	26.7	30.11	26.2
Vitamin B3	15.62	16.25	15.6	15.77	15.67
Vitamin B5	30.98	30.91	26.62	44.44	30.33
Vitamin B6	24.07	24.0	42.47	53.4	41.88
Vitamin B12	44.64	45.0	44.67	53.69	48.59
Vitamin C	23.56	23.61	25.11	29.21	26.23
Vitamin D3	13.47	14.0	11.22	15.38	13.08
Vitamin E	38.66	38.74	50.07	53.22	46.34
Premixes	29.51	29.48	29.49	35.36	31.47
Total	30.1	30.4	32.4	33.8	32.1

Source: Table 14 and Appendix Table 1.
a) The rest of the world includes Latin America, south and east Asia, and Oceania. Because nearly all these countries (except China and Japan) import vitamins, and nearly all have weak antitrust enforcement, overcharge rates are expected to be higher than those in Europe and North America. Following Clarke and Evenett (2002, 2003), the average overcharge for such countries is 33% of sales, which is 25% higher than their estimates for the U.S. and EU. Therefore, the overcharge rates are adjusted to be 20% higher than the mean U.S. - EU rates to allow for lower prices in China.
b) The rates for the U.S. and EU are given equal weights, and the rest of the world a double weight.

PROSECUTIONS OF THE VITAMINS CARTELS

For government trust-busters, the vitamins conspiracies of the 1990s were the greatest catch in antitrust history. Lysine and citric acid pale in comparison to the vitamins case in scope, size, complexity, longevity, or nearly any other conceivable measuring stick. Twenty-one chemical manufacturers fixed the prices of 16 vitamin products in nearly every country[182] of the world for up to 16 years. The cartels' global sales during the conspiracies amounted to grand total of $27 billion, of which almost $8 billion occurred in the United States. Illicit profits made by the cartels totaled more than $8 billion. Fifteen corporations[183] and 15 individuals would be judged guilty of price-fixing felonies.

Government prosecutors did not punish the defendants for ten allegedly cartelized vitamins in the late 1980s. No mention is made in U.S., Canadian, or EU documents that the earlier conspiracies may have existed. The case for price fixing rests with allegations made by plaintiffs in the U.S. treble-damages suits and some fairly compelling, if circumstantial price data (Bernheim 2002a, Kovacic et al. 2006). The absence of indictments for conspiracies in the late 1980s is not proof of innocence because it may simply be explained by the inherent difficulties of obtaining old business records, the unreliability of the memories of witnesses, or the absence of other evidence that can withstand the rigors of a judicial review.

Prosecution began in the United States in 1997. It was an eight-year odyssey.

After an FBI investigation in 1997 failed to turn up sufficient evidence of cartel activity, it was closed. However, evidence provided by buyers of suspicious parallel behavior caused a private damages suit to be filed a year later, and the DOJ's interest was piqued once again. In mid 1998, one of the smaller European members of two cartels offered to plead guilty and cooperate with DOJ investigators. A formal grand jury investigation began in 1998 that eventually cracked the case wide open in early 1999. Canadian prosecutions soon followed, with the Canadian Competition Bureau (CCB) expanding the charges into new vitamin markets. In late 2001, the European Commission issued the first and most sweeping of three vitamins decisions imposing record fines on ten manufacturers. Meanwhile, in the United States and Canada, private damages suits came to an end around 2004 mainly through negotiated settlements. Appeals Courts issued decisions on vitamin-cartel matters as late as 2005.

The United States

The Investigation Phase

The U.S. DOJ had been busy prosecuting the lysine and citric acid cases throughout 1996 and early 1997. These investigations were centered in the DOJ's Chicago and San Francisco offices, respectively. In late 1996 the FBI had received information about a possible price fixing conspiracy in the vitamins industry (Hammond 2001). Initial suspicions focused on the vitamins B3 and B4 markets. In March of 1997, FBI agents working with the DOJ's branch office in Dallas, Texas interviewed Dr. Kuno Sommer in the United States about the matter Barboza (1999). Sommer was the global head of vitamins marketing for Hoffmann-La Roche,

[182] There is some doubt whether the conspiracies affected all of the bulk vitamin markets in Russia and other territories of the former USSR, some of which restricted imports in the 1990s. In the 1980s the USSR was quite closed to trade and appears to have been self sufficient in most of the vitamins. In China, aggressive exporters likely dampened but did not eliminate the effects of global price fixing for four or five products.

[183] Fifteen companies pleaded guilty to felonies, one was found guilty in a civil trial, and four of the 19 perpetrators escaped fines because of the statute of limitations (but the four paid settlements in private civil actions). One of the seven individuals was indicted and remains at large.

the world's leading manufacturer of vitamins. Roche made at least 11 vitamins in plants located in Switzerland, Germany, Scotland, Japan, and the United States. The company was widely reported to enjoy a 45 to 50 percent share of the global markets for bulk vitamins. Sommer also served on Roche's small management committee that formed the pinnacle of the company's management structure. If anyone should have known about vitamins price fixing within Roche, it was Sommer.

Sommer denied that Roche was involved in any such illegal activity. He was interviewed under the March 1997 citric acid guilty-plea agreement in which Roche had promised full cooperation from its employees in any antitrust investigation, so Sommer's denial would have serious legal consequences if he did not answer truthfully. Not only is it a federal felony for the person being interviewed, but also misleading the FBI could cause the Department of Justice to revoke concessions given to Roche itself in the citric acid case. In particular, the DOJ had given Roche a large reduction in its fine, and it had immunized Roche officers from being personally indicted for their roles in the conspiracy. Later it came to light that Sommer had prearranged with others at Roche to lie about the cartel's existence. However, because Roche was the only vitamin co-conspirator with a cooperation pledge in 1997, Sommer's denials must have slowed the FBI's investigation considerably.

In November 1997, the DOJ investigation picked up speed again. Press reports revealed that numerous executives responsible for procuring vitamins for animal-feeds manufacturers were being interviewed about possible price fixing activities in the industry. Moreover, word leaked out that a grand jury had been opened in Dallas, Texas to assist the DOJ in its vitamins investigation. This grand jury would toil away in secret for another 14 months before the first fruits of the investigation would become public. Initial suspicions were focused on the vitamins B3 and B4 industries, but leads began to develop about the larger vitamins A, E, and C markets (Hammond 2001:6-7).

In December 1997 a civil antitrust suit was filed against a large number of vitamins manufacturers alleging a vast price-fixing conspiracy against U.S. buyers of bulk vitamins (Donovan 2005:188-194). The suit was filed by David Boies III[184] of the Birmingham, Alabama firm of Bainbridge & Strauss following publication in November of an article in *The Wall Street Journal* about a grand-jury investigation of vitamins price fixing. In statements to the press couple of years later, Boies' firm would take a great deal of credit for initiating the convictions of the mighty vitamins defendants. While the firm probably shared what information it had about the vitamins cartels, the Dallas DOJ office seems to deserve most of the credit.

By mid-summer 1998 strong and persistent rumors had begun circulating among Washington antitrust lawyers that indictments were likely in the case of vitamins A, C, E, and riboflavin; Roche and BASF were mentioned as targets of the vitamin probe.[185] In March 1998, it would become known that the Dallas grand jury had made considerable progress in two product markets, vitamins B3 (niacin) and B4 (choline chloride), both of which have their main applications in animal nutrition. Two major developments took place behind the scenes. First, in June 1998 or soon thereafter the Ohio firm Bio-Products entered into the DOJ's amnesty program and began to turn over all that its employees knew about the choline chloride cartel. Second, in September 1998, the dominant manufacturer of vitamin B3, the Swiss firm Lonza, was indicted and agreed to plead guilty for criminal price fixing. However, in an unusual move

[184] David III is the son of David Boies II, who is best known for his role as the chief litigator in the U.S. Government's prosecution of Microsoft Corporation for monopolization at a trial in late 1998 (Donovan 2005). In May 1999, David Boies II and his firm Boies & Schiller would become co-lead counsel for the federal class of vitamins plaintiffs.

[185] While grand jury proceedings are almost always secret, those who testify are free to talk about their own testimony, and it is often in the interest of those testifying to pool their information.

for the DOJ, Lonza's indictment and guilty plea were kept secret under a court seal for six months. The most likely explanation for the secrecy is that knowledge about Lonza's cooperation would have alerted other, bigger targets in the vitamin industry and thereby imperiled the DOJ's investigation. Lonza's cooperation was a break for the DOJ's investigation, but it was only a small break.

Lonza Pleads Guilty

One member of the vitamin B3 cartel was the first to be prosecuted by U.S. antitrust authorities. The world's leading manufacturer of vitamin B3, Lonza, pleaded guilty in September 1998, but the company's plea was kept under seal until March 1999. Lonza's guilty plea was vague on the dates of the vitamin B3 conspiracy, merely noting that it began as early as January 1992 and ended sometime around March 1998. Although Lonza's cooperation was secured for the B3 investigation, delays in announcing further guilty pleas suggested that the DOJ probe ran into roadblocks. It is known from subsequent prosecutions that Lonza's co-conspirators were the small New York manufacturer Nepera and the Indiana manufacturer Vitachem. Vitachem was a joint venture between the large German chemical firm Degussa and a smaller Indiana firm, Reilly Industries. The three firms controlled almost 90 percent of the global market for niacin, with Lonza accounting for two-thirds of the presumptive cartel's sales. In the U.S. market the three producers had more equal shares. The vitamin B3 market was not affected by Chinese production.

In retrospect, it seems that Lonza itself must have been the first to come forward sometime in early or mid 1998 and agreed to provide evidence about the vitamin B3 conspiracy. Lonza's cooperation was secured by a fairly small fine (only $10.5 million) and by the DOJ's agreement not to seek criminal charges against any of Lonza's executives. The fact that Lonza did not receive amnesty from the DOJ probably reflects the fact that it initiated the conspiracy; ringleaders do not qualify for amnesty. The relatively large fines imposed on Degussa and Nepera seem to imply that they resisted making guilty pleas for some time.

Lonza's information on the vitamin B3 cartel did not lead the U.S. investigation directly to the main Roche cartels. None of the leading manufacturers in the world's vitamins industry make vitamin B3. However, Lonza does manufacture one other vitamin, biotin (vitamin H). Lonza, together with two German and two Japanese manufacturers, control about 95% or more of the world biotin market. The dominant world producer of biotin with about 45% of the market is none other than Hoffmann-La Roche. Biotin should have been the bridge for U.S. investigators to learn about the larger web of Roche cartels. Yet, oddly the United States, unlike Canada and the EU, never prosecuted any of the five members of the biotin cartel.[186]

Convictions in Vitamin B3

In a very unusual delay, 21 months after Lonza pleaded guilty, in May 2000 three companies and two individuals pleaded guilty to criminal price fixing in the market for vitamin B3. The three manufacturers convicted were Degussa-Hüls of Frankfurt am Main, Germany; Reilly Chemicals, Inc. of Indianapolis, Indiana; and Nepera, Inc. of Harriman, New York. Degussa and Reilly owned a joint venture that made B3 in the United States and a small plant in Belgium. Nepera was a relatively small U.S. manufacturer of B3, but the fact that Nepera's

[186] The biotin cartel ended in late 1995, so the statute of limitations does not seem responsible for the decision not to indict. Shortly after the biotin cartel ended, Lonza ceased production. Lonza might have qualified for amnesty in the B3 case by informing the DOJ about the biotin cartel.

President and Vice President for sales were the only two persons convicted in this cartel suggests that Nepera was one of the companies resisting a plea bargain.

The plea agreements for Lonza, Degussa, and Nepera admit that each of the companies began conspiring "as early as January 1992." U.S. transaction prices show a suspicious jump in B3 prices in 1991. Both Nepera and Degussa seem to have resigned from the cartel in July 1995, but in Degussa's case it handed on its conspiratorial role to its joint-venture partner, Reilly Industries.[187] Prices declined for five years thereafter. When the conspiracy ended in March 1998, the two largest U.S. sellers of B3, Lonza and Reilly, were still conspiring.[188] In addition, the DOJ stated that there were unnamed co-conspirators that were not indicted. By May 2000, four companies had paid $33.5 billion in criminal fines, and two Nepera executives were to be sentenced to a total of 20 months in prison. Degussa seems to have paid the largest U.S. fine relative to its sales during the conspiracy, a sign that it was uncooperative with the DOJ.

The Big Three Plead Guilty

With fairly solid evidence of a broad conspiracy in several vitamins markets in the hands of government investigators by late 1998, in the time-honored fashion of prosecutors everywhere, they turned the screws tighter on the smaller vitamins manufacturers. Rhône-Poulenc was a vulnerable target. It was the smallest of the Big Three vitamin manufacturers, holding about 9 percent of the global market. Rhône-Poulenc was amenable to a deal because it had previously announced its intention to merge with Hoechst, and such a merger could not be consummated if the uncertainty of severe price fixing sanctions hung over their heads. Whatever Rhône-Poulenc's motives, it agreed in late 1998 to cooperate with the DOJ's broader vitamins investigation. In fact, Rhône-Poulenc was formally admitted into the DOJ's amnesty program after it provided crucial evidence for prosecutors. Not only did its executives, who were deeply involved in colluding on vitamins A, E, B2, and B12, begin to provide incriminating details, but also its vitamins managers gave the DOJ the kind of evidence that is most persuasive with juries – tape recordings of an actual cartel meeting.[189] The meeting in February 1999 was one of "Vitamins Inc.'s" top-flight occasions, with all of the companies' top officers present. The cartel had at that time gone into deep cover, so this last meeting was probably held in one of the participant's private homes in Switzerland or Germany.[190] When the DOJ approached the lawyers representing Roche and BASF with the overwhelming evidence provided by their former co-conspirator Rhône-Poulenc, the two cartel ringleaders quickly agreed to plead guilty.

DOJ negotiations in March to May of 1999 mainly involved the size of the corporate fines to be paid by Roche and BASF and the number of executives to be indicted. The DOJ was in a strong bargaining position because of its trial victory in late 1998 over three ADM executives in the lysine case. Under the twice-the-harm rule for sentencing of corporate felons, Roche was presented with the doubtless astounding news that their company was facing U.S. fines of up to

[187] There may have been a change in ownership or management of the joint venture, Vitachem, Inc. Reilly's participation began in September 1994. It paid the lowest fine of the four conspirators ($2 million). Nepera's exit may also be explained by its take over in 1995 by Cambrex Corp., which was not charged by the DOJ.

[188] It is not clear if the unnamed co-conspirators might be corporations or individuals. No executives from either Degussa or Reilly were required to plead guilty, so they were probably granted immunity.

[189] The existence of such tapes has not been formally acknowledged by the DOJ, but when asked about it at a press conference, Gary Spratling artfully avoided denying it. Barboza (1999) accepts the story.

[190] In the European Union, European Commission investigators can only search places of business for documents, not private homes.

$1.9 billion (plus about $2.8 billion in tag-along civil penalties).[191] BASF was liable for up to $640 million in U.S. fines. Although the third and fourth to agree to plead guilty, a major concession offered to Roche and BASF by the DOJ was the right for both companies to be designated in second place when applying for leniency.[192] A second place position confers the expectation that the applicants will receive the second largest discounts on their fines. The DOJ would later praise Roche and BASF for their exemplary cooperation.

The DOJ prosecutors likely pointed out the material benefits of a downward departure in their ultimate fines if only they too would cooperate. The decision to pay even the greatly reduced fines offered by the DOJ was obviously not an easy one to make for Roche and BASF. There is a revealing detail in the plea agreement signed by BASF, an appended letter from its general counsel to the DOJ dated May 18, 1999 committing BASF to plead guilty under the DOJ's terms: the meeting of BASF's Executive Committee at its Ludwigshafen headquarters to approve the deal must have been rancorous, because it lasted seven and one-half hours.

On May 19, 1999 the *Wall Street Journal* announced to the world that momentous guilty pleas of price fixing in the vitamins industry would be made public the next day. The announcement day itself was full of dozens of coordinated events. In the morning of May 20th, a press conference was held at the headquarters of the Department of Justice in Washington, attended by the Attorney General Janet Reno, the Assistant Attorney General for Antitrust Joel Klein, and many other top officials of the DOJ and FBI. At about the same time, officers of Roche and BASF appeared with DOJ prosecutors in U.S. District Court in Dallas, Texas to file their guilty pleas and explain to the Court how the fines and jail sentences were arrived at. The DOJ and the Big Three vitamins makers also released statements to the press. Rhône-Poulenc's statement admitted that it had engaged in criminal price fixing and would face harsh civil penalties in the future for its crimes; it also pointed out that it had been admitted to the DOJ's amnesty program and thereby would save tens of millions of dollars in potential U.S. penalties. Joel Klein spent much of the day being interviewed about the plea agreements. The world's business press would be filled with news of the deal the next day.

The deals involved an almost unimaginable stepping up of price fixing sanctions. Hoffmann-La Roche agreed to pay $500 million in fines, almost five times the previous record antitrust fine. BASF paid $225 million. These fines were roughly proportional to each company's U.S. and global market shares. (Had Rhône-Poulenc been fined, it could have paid as much as $450). As the "second firms" to confess and with promises to cooperate, Roche and BASF were entitled to great leniency (Spratling 2000). Although a huge public relations coup for the DOJ, both fines reflected discounts of 65 to 75% from what could have been obtained had the DOJ gone to court and won in trial (Appendix Table 13). As odd as it may sound, settling for $725 million in fines was a good deal for the defendants.

Information on how the 1993 DOJ leniency program works was well publicized in speeches by antitrust officials (e.g., Spratling 2000). Amnesty is granted to the first firm to confess to its role in a criminal antitrust conspiracy, but only if the DOJ was unaware of the cartel and the first-comer was not a leader or enforcer in the cartel. That is, the first to offer this valuable information and to agree to cooperate automatically receives a 100-percent discount on the fine specified by the U.S. Sentencing Guidelines. However, the second firm to confess also receives a substantial break as well, typically a 50- to 80-percent discount from what is specified by the Guidelines.[193] Attracting a second cartel member to the prosecutors' side is

[191] Roche imposed an estimated $942 million in overcharges on U.S. direct buyers of vitamins in 1990-1999, an amount that can be doubled to calculate the government fine and tripled as an award to direct buyers (Appendix Table 13). Similarly, BASF generated $320 million in U.S. overcharges.

[192] Spratling (2000) would later assert that Roche and BASF were "tied for second place" after Rhône-Poulenc, but he is not counting Lonza for some reason.

[193] As a ringleader Roche was not qualified to be granted full amnesty, but could qualify for second-place.

important if the other conspirators decide to go to trial. If a cartel is large enough to have third and fourth firms, they too may apply for leniency, but their fines will involve successively smaller discounts from their maximum fines. The degree of leniency will increase for these late-arrivals if they are quick to confess, relatively small players in the cartel, offer valuable information, created modest overcharges, or can show that the conspiracy was not condoned by top management (Spratling 2000).[194]

Besides the corporate fines eight senior executives of Roche and BASF were indicted for criminal price fixing. The four Roche officials were Dr. Kuno Sommer (former head of global vitamins marketing, promoted to President of Roche's fragrances and flavoring division), Dr. Hugo Brönnimann (President of the vitamins division), Andreas Hauri (head of global vitamin marketing), and a former Roche executive whose name is secret.[195] At BASF, four officers with similar positions were indicted: Reinhard Steinmetz, Dieter Suter, Dietz Kaminski, and Hugo Strotmann. In addition to these eight, ten more managers were listed by name as unindicted co-conspirators. While all eight top executives were fined, the DOJ saved its harshest treatment for Kuno Sommer. He had not only fixed prices but also made false statements to DOJ investigators in March 1997. In addition to a $100,000 personal fine, Sommer had to agree to a four-month prison sentence. This was the first time in U.S. antitrust history that a European had agreed to serve prison time for price fixing.

At its press conference, DOJ officials were grave and scolding. Janet Reno began by saying that the $500 million fine was,

> ". . . the highest fine the Justice Department has ever obtained in any criminal case. We mean business."

Joel Klein elaborated on the DOJ's view:

> "The vitamin cartel is the most pervasive and harmful criminal antitrust conspiracy ever uncovered . . . The enormous effort that went into maintaining the conspiracy reflects the magnitude of the illegal revenues it generated . . . These cartels . . . are powerful and sophisticated and, without intervention by antitrust authorities, will often go on indefinitely."

Klein's assistant Gary Spratling provided added a pithy characterization:

> "Simply put, the vitamin cartel was as bad as they get."

When asked by a reporter why he thought the vitamin cartel lasted so long, Spratling gave three reasons. First, the Antitrust Division had only stepped up its efforts directed at global price fixing since the 1995-1996 lysine cartel case. Second, the conspirators had gone to great lengths to

[194] It is difficult to reconcile all of Spratling's criteria with the actual outcomes of these two cases. For example, Roche and BASF were tied for second place in the race for leniency in vitamins, yet the second largest ringleader (BASF) got a smaller percentage discount than the number-one ringleader. The later arrivals in this populous cartel also received discounts that were larger than the promised percentages. In sum, the DOJ was more lenient than its policy dictated.

[195] The unnamed executive is probably a retired predecessor of Sommer or Brönnimann who will be apprehended if he tries to enter U.S. territory. Hauri was one of the Roche officials first contacted by ADM's Terrance Wilson and Barrie Cox when they first traveled to Europe to launch the citric acid cartel (Connor 2001). Hauri paid the largest monetary fine for his recidivism.

cover up their conspiracy. Third, the DOJ's leniency program had been very useful in attracting Rhône-Poulenc's cooperation, but the 1993 revision needed years to become well known.

A day after the DOJ press conference, the Chairman of Roche, Franz Humer, and the company's CEO met with the press. Humer said:

> "I am personally absolutely shocked at what has happened. You will understand that this was not part of our responsibility. We really don't know what [the Roche price fixers] did."

He claimed to have learned of the conspiracy only in February 1999; two previous internal investigations by the company in 1997 and 1998 (in response to civil suits brought against Roche by vitamin buyers in the United States) had failed to uncover any skullduggery. Huber said that he would take steps to avoid a repetition of antitrust offenses, but his plan was rather vague. The only concrete step taken was firing Kuno Sommer and Hugo Brönnimann; the six other managers mentioned in Roche's guilty plea agreement were left in their jobs.

Humer's performance at this press conference raised a chorus of critical comments. In an article laced with acid language, *New York Times* writer Edmund Andrews derided Humer's statements:

> ". . . the chairman and chief executive of Roche Holdings AG pronounced themselves blameless and clueless . . . "

An article appearing in the *Financial Times* of London commented that:

> "The fine is a severe blow to the reputation of Roche, one of the world's oldest and most conservative pharmaceutical companies."

Industry analysts were not long in issuing glum predictions about the financial implications for Roche *et al*. By June 1999, they were speculating that the total antitrust costs for the defendants would be at least $2 billion. Although promptly denied by Roche, one chemical-industry analyst estimated that Roche alone would face antitrust liabilities of $1 billion or more and might want to sell its vitamins/fine chemicals division. The analyst's statement would turn out to be prescient but short of the mark. Five years later Roche did sell its vitamins division, but its antitrust bill would amount to $2.5 billion.

In October 1999, a Roche spokesperson was interviewed about the vitamin conspiracy. In a statement that is quite revealing about the company's continuing attitude of myopic self-deception, she said:

> "We can't dispute the facts and we've decided it is of no value to unravel it. The situation is behind us. We've paid dearly for it."

Public-relations specialists often see their role as putting a positive spin on any adverse news facing their employers or clients. The truth is that Roche and its fellow conspirators in vitamins still faced a bewildering array of legal problems. The civil suits in the United States and Canada were still being filed or negotiated (see Chapter 16). More to the point, Roche *et al*. were besieged by investigations by antitrust officials of many nations, and several of these actions were at early stages in late 1999.

Smaller Firms Plead Guilty

The press releases of the U.S. Department of Justice make it clear that it regarded each of the punished[196] nine vitamins cartels as cogs in one vast machine of collusion.[197] Although the fines meted out on the first three companies would account for 80% of the total, ten more corporate guilty plea agreements followed those of Lonza, Roche, and BASF. The fines came in three waves of public announcements.

This time it was *USA Today* that broke the news about further indictments in its June 17, 1999 edition. Seven companies and the vitamins they made were specifically mentioned. The first wave of post-Roche guilty pleas came on September 9, 1999. Takeda Chemical Industries, Eisai Co., and Daiichi Pharmaceutical paid fines of $72, $40, and $25 million, respectively, for price fixing in the markets for vitamins E, C, B2, and B5. It is typical for conspirators that take longer to admit their guilt to be fined at a higher rate than companies that settle early and cooperate. Negotiations with these three companies had dragged on for about seven months. However, the fine paid by Eisai was discounted by 75% -- the same rate as had been accorded Roche and BASF (Appendix Table 14). That is, Eisai was treated as though it too was "second in line" for leniency. The other Japanese firms, Takeda and Daiichi, received generous discounts of 59% and 40%, respectively. Given that Takeda was the ringleader of at least six Japanese cartelists, the reason for its large discount is particularly difficult to square with DOJ fining policy. No officers of the three companies were individually sanctioned.

The large U.S. fines paid by the three Japanese chemical companies were widely reported in the companies' home country. Perhaps to counter the adverse publicity, the companies imposed on themselves additional sanctions. At Takeda Chemical Industries all employees were to be required to take new training in antitrust principles. The company's president, Kuno Takeda, took a 15 percent pay cut for three months, and all members of the board of directors ordered a 5%, three-month pay cut for themselves. Moreover, Kuno Takeda resigned his post as Chairman of the Japan Federation of Pharmaceutical Manufacturers. Daiichi and Eisai announced very similar sanctions for their boards, presidents, and employees on the same day. Although there is a certain ritualistic flavor to their public self-flagellation, at least it makes the point that the companies' entire governance structures accept some of the burden of responsibility for the companies' criminal behavior. In any case, the Japanese companies' responses stand in stark contrast to the "clueless and blameless" stance of Roche's top officials.

Later in September 1999 the second, much delayed corporate conviction for choline chloride was announced. Chinook Group Ltd. of Canada became the 8th firm prosecuted in the vitamins scandal. Recall that Chinook's co-conspirator had confessed to price fixing 15 months earlier and that the FBI had raided Chinook's offices one year earlier. These actions should have yielded considerable evidence against Chinook. On the other hand, previously two of its officers had been indicted for the same crime but had refused to plead guilty or otherwise cooperate. Moreover, it is also apparent that the third participant in the cartel, DuCoa and its managers were also refusing to cooperate with prosecutors.[198] These developments indicate that because of resistance by the company's owners and management the DOJ had considerable trouble obtaining corporate guilty pleas from both Chinook and DuCoa. At

[196] The DOJ did not fine the participants of seven cartels. Reasons are discussed below.

[197] For example, in a September 30, 2002 release about a fine on a choline chloride defendant, the Assistant Attorney General for Antitrust is quoted as saying: "This latest case, the 29th in the long running and highly successful vitamins investigation…"

[198] Despite pressure applied by the DuCoa's parent company, DuCoa's owners did not agree to plead guilty until September 2000. DuCoa's President and three other officers responsible for its price fixing were indicted but not sentenced until 2004.

Chinook, two U.S. employees (John Kennedy and Robert Samuelson) and one Canadian employee (Russell Cosburn) ware found guilty of felonious conspiracies. Yet considerable evidence led a U.S. court to conclude that the two controlling owners of Chinook were also aware of and encouraged the price fixing; they were Robert Copeland and Patrick Stayner, CEO and VP for Finance.[199] Yet, neither Copeland nor Stayner were indicted by U.S. or Canadian authorities.

Chinook agreed to pay a $5 million criminal fine for its role in the price fixing vitamin B4. Chinook was the largest member of and instigator of the North American branch of the choline chloride cartel. Under the double-the-harm standard, Chinook was liable for a U.S. fine of up to $145 million. Instead, its 97% discount suggests that the collapse of prices in the choline chloride market had driven Chinook into poor financial shape. Normally, it would have been the most heavily fined but for its inability to pay.

The DOJ winded down its investigation in 2000. The second wave came in May 2000. Four corporate and two personal price fixing convictions were announced that came close to tidying up the slate. The Darmstadt, Germany-based pharmaceutical firm E. Merck pleaded guilty to fixing the price of vitamin C and agreed to pay a $14 million fine. Roche, BASF, and Takeda had previously admitted their guilt in the vitamin C case, and E. Merck would be the last member of this cartel to be punished. In addition, three companies were convicted in the vitamin B3 cartel: Degussa-Hüls (Germany), Nepera (a subsidiary of the U.S. firm Cambrex Corp.), and Reilly Industries (a privately owned Indiana firm). Degussa was awarded the smallest antitrust-fine discount of any of the 13 vitamin cartelists, a paltry 29%. The distribution of the $19 million in fines suggests that Degussa was a co-leader of the cartel, but its high fine may also have been a consequence of recalcitrance in settling with the government. Degussa's guilty plea came 18 months after the largest member of the B3 cartel (Lonza) had capitulated and agreed to supply the DOJ with information. Degussa's small discount is also surprising because its partner in crime, Reilly Industries, was granted a 78% downward departure from the maximum.[200]

The fourth member of the vitamin B3 cartel was Nepera, which was the smallest company in the vitamin B3 cartel. Its $4 million fine was one of the most heavily discounted (83%). Its large discount probably reflects a low ability to pat the fine. Both of the men convicted and given prison sentences were Nepera executives. As the DOJ usually reserves the right to insist on prison sentences only for ringleaders of cartels, their imprisonment probably signals an initial refusal to accept responsibility for their actions.

Much later, in September 2002, the second member of the choline chloride conspiracy, DuCoa, pleaded guilty and paid $500,000, by far the smallest fine of the 13 convicted firms in the United States. Three of DuCoa's officers pleaded guilty, and its last president was convicted at trial in Texas in December 2004 (DOJ 2005). He received the longest prison sentence (30 months) of any of the convicted vitamins defendants. It appears from this turn of events that the owners of DuCoa might not have been aware of the price fixing going on in the company's vitamin sales department. From 1988 to 1997, DuCoa was a 50-50 joint venture of the giant

[199] Prosecution of Chinook, Ltd. was also complicated by its ownership structure (see *In Re: Vitamins Antitrust Litigation, Misc No. 99-197 (TFH), MDL No. 1285)*. Chinook, Ltd. was the manufacturing entity that controlled its U.S. manufacturing subsidiary Chinook Inc., a Minnesota corporation. However, both of these operating entities were owned and controlled by a Canadian holding company, Cope. Peter Copeland was President and Chairman of both Cope and Chinook, Ltd., and all of Chinook's senior management reported directly to Copeland, including the VP for Sales Russell Cosburn who was imprisoned for price fixing in Canada. Copeland testified that he was aware of the meetings and authorized Cosburn and Stayner attendance at the meetings. Copeland and Stayner personally attended at least two of the price-fixing meetings.

[200] Recall that Reilly and Degussa were joint owners of a production and marketing joint venture; as far as is known this subsidiary was equally controlled by the two parents.

chemical company DuPont and the equally huge food manufacturer ConAgra. DuCoa's case is unique in that the company was sold to a new owner, DCV Corp., during the middle of the vitamin B4 conspiracy. DCV maintains that it knew nothing of the price fixing. Indeed, DCV has sued DuCoa's former owners, DuPont and ConAgra, for failing to reveal a material fact prior to the acquisition of DuCoa. The imposition of a nominal fine on DuCoa lends credence to the notion that the company's new owners had no knowledge of the conspiracy.

To sum up, thirteen chemical companies were convicted by the United States for price fixing in markets for bulk vitamins. U.S. fines on the unlucky 13 accumulated to $915 million (Tables 16 and 17). These monetary sanctions are also expressed in real (2005) dollars in Table 17A. In addition, 16 senior executives of the vitamins manufacturers were criminally indicted and received 16 personal sentences that averaged $110,000 in fines and 8 months in prison.[201] The most injurious cartels in the past half-century were also the most expensive for the perpetrators.[202]

Table 16. Global Monetary Antitrust Sanctions, by Company, 1999-2006

Companies	Fines [a]				Private Suits [d]	Total
	U.S.	Canada	EU	Other		
	Million nominal U.S. dollars					
Roche	500.0	42.0	410.0	9.3	2100-3000	3061-3961
BASF	225.0	16.2	308.4	4.3	761-1081	1315-1635
Rhone-Poulenc	72.0	2.8	32.9	0.0	226-323	409-579
Takeda	0 [b]	11.6	4.5 [b]	2.8	390-560	334-431
Eisai	40.0	1.7	11.7	0.2	149-212	204-267
Daiichi	25.0	2.1	20.8	0.1	79-112	128-161
E. Merck	14.0	0.45	8.2	0	94	92-122
Lonza	10.5	0.5	29.2	0	57	97.2
Mitsui/Bioproducts	0 [f]	0.3	0	0	53.4	54
Tanabe	0	0	0 [c]	0	60-80	60-80
Akzo Nobel	0	0.45	28.0	0	14-16	42-44
UCB	0	0	13.8	0	17-19	31-33
Degussa	13.0	1.1	0	0	17	31
Sumitomo	0	0	0 [c]	0	35-46	35-46
Chinook	5.0	1.0	0 [c]	0	6.9	13.1
Solvay	0	0	8.1	0.01	0	8.1
Nepera	4.0	0.10	0 [c]	0	8.0	12.1
Reilly	2.0	0.02	0	0	10.0	12.0
Hoechst	0	2.0	0	0	2-3	4-5
DuCoa	0.5	0	0 [c]	0	0.4	0.9
Kongo	0	0	0 [c]	0	0	0
Total	915 [g]	83.1	847.6	16.4	4000-5700	6200-7600

[201] A few were not sentenced as of early 2006.

[202] The affected sales of the great U.S. electrical power-generating-equipment cartel were estimated to be $7 billion per year in the 1950s for a similar duration.

Source: Appendix Table 2. Revised 3/08.
-- No information, no sales in the jurisdiction, or pending
a) Fines announced as of early 2006 by U.S., Canada, EU, Australia, and Korea. EU investigations of vitamins B3 and B12 may be pending.
b) Amnesty for vitamins A&E.
c) Guilty but saved by the statute of limitations.
d) U.S. settlements widely reported to be more than $2 billion. Includes settlement by National Association of Attorneys General for $335 million for indirect buyers in 23 states ($305 mil.) and 43 states as direct buyers ($30 mil.). Legal defense fees are probably 5-10% more than settlements payouts. Also includes Canadian private suits totaling $105 million.
e) Annual report 2000 said "total losses" were 5.7 billion yen (about $188 mil.).
f) Amnesty for vitamin B3.
g) Includes fines on 16 individuals.

Table 17. Monetary Sanctions by Vitamin Product, 1999-2006

Product Market	U. S. Govt.	Private [b]	Canada	Europe	Rest of the World	World
	Million nominal U.S. dollars [a]					
Beta carotene	62	260-374	4.1	81	0	412-516
Canthaxanthin	0	7-11	0	78	0	85-89
Biotin (H)	0	109-147	0	0	0	109-147
Choline chloride (B4)	5.5	141-167	1.6	88	0	236-262
Folic acid (B9)	0	19-28	0	0	0	19-28
Vitamin A	97	563-806	8.6	117	5.6	792-891
Vitamin B1	0	43-61	0	0	0	43-61
Vitamin B2	28	102-145	1.5	62	0	196-238
Vitamin B3	30	90	2.1	0	0	123-130
Vitamin B5	39	123-177	3.1	99	0.1	266-320
Vitamin B6	0	40-67	0	0	0	40-57
Vitamin B12	0	9-13	3.8	0	0	12-16
Vitamin C	175	645-905	11.9	104	5.4	948-1164
Vitamin D3	0	0	0	38	0	38
Vitamin E	262	1231-1764	16.9	180	5.8	1715-2247
Premixes	218	1124-1387	28.3	0	0	1124-1387
Total	915	4000-5700	82.3	847	16.9	6200-7600

Source: Appendix Table 2.
a) The EU assigns fines by product, but most other fines and settlements are allocated by the affected sales of the product and then within the product by company market share. Converted C$1 to US$ 0.826.
b) Includes US and Canadian private settlements for damages to direct and indirect purchasers. Canadian settlements were slightly higher than the fines. Includes legal fees paid to plaintiffs' counsel.

Table 17A. Real Monetary Sanctions by Vitamin Product, 1999-2006

Product Market	U. S. Govt.	Private	Canada	Europe	Rest of the World	World
	2005 U.S. dollars [a]					
Beta carotene	34.07	162.72	2.27	41.44	0.00	240.49
Canthaxanthin	0.72	4.62	0.00	40.16	0.00	45.50
Biotin (H)	0.00	49.37	0.00	0.00	0.00	49.37
Choline chloride (B4)	2.12	59.40	0.64	32.90	0.00	95.06
Folic acid (B9)	0.00	9.06	0.00	0.00	0.00	9.06
Vitamin A	48.62	318.79	4.32	54.33	2.77	428.83
Vitamin B1	0.00	20.06	0.00	0.00	0.00	20.06
Vitamin B2	12.67	51.86	0.68	25.90	0.00	91.11
Vitamin B3	14.88	41.92	1.01	0.00	0.00	57.80
Vitamin B5	18.35	69.86	1.56	45.96	0.05	135.77
Vitamin B6	0.00	20.64	0.00	0.00	0.00	20.64
Vitamin B12	0.00	4.24	1.58	0.00	0.00	5.82
Vitamin C	72.77	298.94	4.95	40.11	2.21	418.97
Vitamin D3	0.00	0.00	0.00	19.41	0.00	19.41
Vitamin E	131.41	697.43	8.48	83.60	2.87	923.80
Premixes	109.54	584.72	14.20	0.00	0.00	708.46
Total	445.1	2393.6	39.7	383.8	7.9	3270.1

Source: Table 17

a) The EU assigns fines by product, but most other fines and settlements are allocated by the affected sales of the product and then within the product by company market share. Converted C$1 to US$ 0.826. This table shows the mid point of ranges in Table 17. To allow for the opportunity cost of capital (i.e., the absence of prejudgment interest), fines and settlements are adjusted downward by the U.S. prime rate of interest plus 1% from the midpoint of the conspiracy to the year the cartel was fined; then from the latter year, the figure is raised to $2005 using the producer price index of the appropriate region.

Ten That Got Away

Eleven of the 21 corporate participants were indicted by U.S. DOJ. Two of the 11 pleaded guilty but were given amnesty for being the first to come forward with information to prosecute the remaining cartelists and their managers.

How can two firms be first? As related above, Rhone-Poulenc offered to cooperate in the DOJ's on-going vitamins investigation sometime around December 1998. Rhone-Poulenc had become an early participant in two of the largest Roche-organized cartels – vitamins A and E. The second firm to be designated first in line for amnesty was Bio-Products, an Ohio manufacturer of choline chloride controlled by the enormous Japanese trading company Mitsui & Co. (Barnett et al. 2005: 29).[203] It is possible that Rhone and Bio-Products were tied for position, but this is unlikely. A more reasonable explanation is that as a legal matter the DOJ, despite pronouncements to the contrary, viewed the chlorine chloride cartels as almost entirely separate from the other 15 vitamins cartels.

Bio-Products gave sufficient information to the DOJ to convict two North American manufactures, Chinook and DuCoa, for criminal price fixing. The President of Bio-Products also testified at trial against the president of DuCoa (*ibid.* p.8). However, Akzo Nobel, BASF, and UCB, the three members of the European branch of the choline chloride cartel, were not indicted by the DOJ. By agreeing to stop exporting to the North American market from 1992 to 1998, these firms were directly responsible economically and legally for the price increases in the United States.[204] Even if Bio-Products had no information on this strategy, both Canada and the European Commission were well informed about the European branch. Moreover, the three European manufacturers paid substantial settlements to U.S. buyers to settle a class action. Thus, unless justified by a decision to conserve prosecutorial resources, the DOJ's inaction is puzzling.

The DOJ declined to indict companies that arranged cartels in seven markets: vitamins B1, B6, B12, D3, folic acid, biotin, and canthaxanthin. This decision affected three Japanese manufactures of biotin and folic acid. While Roche was the world leader in these two products, Sumitomo, Tanabe, and Kongo Chemicals each held 15 to 20% global market shares in the two markets and caused an estimated $20 million in overcharges in the U.S. market. Neither the inability to pay nor the statute of limitations were factors inhibiting prosecution of the sellers in these two cartels. It is true that folic acid was an exceptionally small market (less than $12 million in affected sales), but the biotin market was substantial ($144 million).

In the case of vitamins B1 and B6, the participants were companies fined for their participation in other cartels. Neither lack of information nor the statute of limitations explains the DOJ's inaction. Both cartels generated modest U.S. sales ($104 million) and equally modest overcharges (about $14 million). The vitamin D3 cartel had $72 million in affected commerce and $10 million in overcharges. By failing to prosecute, Solvay got a pass on U.S. fines.

Hoechst was the junior member of the global vitamin B12 cartel, which it dominated along with Rhone-Poulenc. Neither manufacturer was indicted for fixing prices in this medium-size market ($112 million in affected U.S. sales). As mentioned previously, the fact that Rhone and Hoechst were planning to merge was a likely factor in Rhone's decision to seek amnesty.[205] It is likely that the DOJ's failure to press ahead with legal action in vitamin B12 was a concession to Rhone when it agreed to confess. Without such a deal, the two firms faced fines of up to $82 million.

[203] Mitsui denies management control, but in a 2005 U.S. civil trial a jury found otherwise. Mitsui saved a possible $98 million fine when it was accepted into the amnesty program.
[204] Calculating the damages to the U.S. market from this behavior may be more challenging than for the other cartels.
[205] The merged company (Aventis) became a reality in December 1999.

Finally, the DOJ did not prosecute the cartel that fixed the prices of canthaxanthin and other carotenoids. The industry is a duopoly of Roche and BASF; their conspiracy generated $116 million in U.S. sales and $24 million in overcharges. Their omission is a mystery.

To summarize, ten out of 21 corporations that engaged in vitamins collusion in the 1990s received no fines in the United States. Two of them were large companies that sought and received full amnesty, while the remaining eight firms were generally small ones. Two of the three large European manufacturers that had by agreement withheld exports of vitamin B4 to the United States were unsanctioned by the DOJ. Moreover, no fines were imposed for price fixing in any markets with less than $150 million in affected commerce, namely, vitamins B1, B6, B12, D3, folic acid, biotin, and canthaxanthin. While each of these cartels was relatively small, the aggregate amount of affected U.S. commerce was significant -- $560 million or 7.4% of the total. As a result, eight cartelists escaped criminal prosecution. No impediments to prosecution were noted, so the reluctance to indict seems to rest upon in a decision to conserve prosecutorial resources.

Canada

The cartels in the global bulk vitamins markets attracted more coordinated enforcement activity outside the United States than any others in history. At least eight jurisdictions launched formal antitrust investigations of price fixing: Canada, the European Union, Switzerland, Japan, Australia, New Zealand, Brazil, and Mexico. No where was there a greater determination to prosecute swiftly and vigorously than in Canada.

The Canadian Competition Bureau (CCB) began its investigation sometime before early 1999, aided by long-standing cooperative agreements and years of actual coordination in cartel matters with the U.S. DOJ. On September 22, 1999 the CCB recommended precedent-setting corporate fines for five vitamin manufacturers, and the Federal Court of Canada agreed to accept its recommendation. Officials said that prices of vitamins were pushed as high as 30 percent above competitive levels.

Fines of Canadian $85.5 million were imposed on Roche Holdings, BASF, Rhône-Poulenc, Eisai, and Daiichi for nine of the vitamins cartels in A, C, E, B2, B4, B5, B6, beta carotene, and premixes. Unlike the United States, vitamin B6 was listed as one of the cartelized markets.[206] Affected sales in Canada by the five defendants totaled between C$650 and C$700 million. These were by far the largest criminal fines in Canadian legal history. The federal prosecutor stated that these fines "were big enough to eliminate most illicit profit" made by the cartel in Canada[207], but he admitted that the defendants were given a discount below what could have been imposed by the Court, mainly because the guilty pleas spared the Crown the expense of litigating a conviction. He noted that the defendants still faced monetary penalties from civil suits; class-action suits have been permitted in Canada since 1992 but seldom had been litigated at that time.

Additional corporate fines were imposed by Canada's courts over the next four years. On September 24, 1999, Chinook Group Ltd. was fined C$5 million; the VP for sales of Chinook was sentenced that same month to nine months of confinement to be served as community service. The last participants in the choline chloride conspiracy to be sentenced (in August 2003) were Akzo Nobel and Bio-Products, which were required to pay C$1 and $0.8 million fines, respectively. Neither UCB nor DuCoa were indicted.

[206] Another difference is that BASF was fined for its role in preventing exports of choline chloride to Canada, a violation ignored by the DOJ.

[207] In fact, in real terms only 25% of the profits were disgorged by Canada's fines.

On October 20, 1999 Hoechst was fined C$370,000 for colluding in the market for vitamin B12. The other Canadian supplier, Rhone-Poulenc, was not punished for fixing the price of this vitamin. Neither the United States nor the EU fined any companies for the vitamin B12 conspiracy, though both firms did pay U.S. buyers civil settlements for this product.

On February 24, 2000 Takeda agreed to pay a C$5.2 million fine for its role in the vitamins C and B2 cartels. On March 30th of that year E Merck was also fined C$1 million for vitamin C. Takeda and Merck completed the quartet of firms responsible for global collusion in vitamin C.

The next-to-last corporate prosecutions by the Canadian government were announced on October 16, 2002. Degussa, Lonza, Nepera, and Reilly were forced to pay C$3.9 million in criminal fines in the vitamin B3 case. That amounted to a total of 15 corporate convictions and almost exactly C$100 million in fines for about C$824 million in Canadian affected commerce. In addition, four businessmen from Switzerland, Germany, and Canada were convicted and paid C$650,000 in fines.[208] Converted to nominal U.S. dollars, the totals amounted to about $83 million in fines and $550 million in sales – approximately a 15% ratio.

The European Union

On May 20, 1999, the DOJ trumpeted its second and largest wave of sanctions. Later that month the EU's antitrust chief, Karel van Miert, stated that Roche, BASF, and Rhône-Poulenc were cooperating with its investigation. Van Miert also prepared the European public for lower fines than those imposed by the United States. Shortly thereafter a new Competition Commissioner took over the helm of DG-COMP – Mario Monti.

The Roche Cartels

In the week before the DOJ's momentous vitamins-prosecution announcement, the Big Three vitamin manufacturers rushed to Brussels (EC 2001). Already alerted to Rhone-Poulenc's membership in the DOJ's amnesty program, on May 4th Hoffmann-La Roche wrote to the Commission and informed it of the company's intention to cooperate with any investigations of cartel activity; on May 6th BASF did likewise; and on May 17th Roche and BASF jointly visited the Commission and repeated their intention to cooperate. However, in what may have been a costly decision, neither company handed the EC a written statement (a proffer) or documentary evidence that month.[209] Meanwhile, on May 12th Rhone-Poulenc announced to the EC that it had violated the EU's competition law and that it sought leniency under the Commission's Leniency Notice of 1996. Later, the EC would decide that Rhone-Poulenc was qualified to meet all the conditions of its leniency program.[210]

The EC's investigation officially begins when it sends letters to targets requesting information about possible violations. From June to October 1999 the DG-COMP received letters and documents from 11 members of the vitamins cartels. All but Sumitomo admitted to anti-competitive behavior. After about a year of study DG-COMP had arrived at preliminary conclusions about the guilt of the responding corporations.[211] In July 2000, the European Commission sent its Statement of Objections (legal warnings that are similar to target letters in the United States) to 13 vitamin manufacturers informing the companies that they were the objects of a price-fixing probe. The Commission's mailing included a redacted copy of its investigation file. The next step is for the targeted companies to respond to the Commission's preliminary factual findings, either in writing or at a confidential oral hearing. Ten of the targets

[208] They are Russell Cosburn of Chinook and three former employees of Hoffmann-La Roche, Roland Brönnimann, Andreas Hauri, and Kuno Sommer.

attended an oral hearing held on December 12, 2000 and all but two accepted the Commission's findings.

The Commission's conclusions and its response to objections by the parties are contained in a dense 89-page decision dated November 21, 2001; a slightly redacted version was released on June 10, 2003. Counting Rhone-Poulenc and Hoechst as two entities, the decision identified 14 violators as having cartelized the markets of 14 bulk vitamins from periods beginning as early as December 1998 to as late as February 1999.[212] Like other antitrust authorities DG-COMP did not investigate hints of vitamin cartel activity in the 1980s.[213] Unlike U.S. and Canadian practice, the EC regarded each of the 12 cartels as somewhat separate violations. The decision did not address allegations of cartels in vitamin B3, B4, B12, or vitamin premixes.[214] The EC vitamins decision is a treasure trove of information on the industrial structure, economic dimensions, and behavior of the vitamins cartels.

The EC ordered 11 of the 14 companies to pay fines that totaled an impressive $759 million, an amount only slightly lower that that imposed by the United States (Table 17). The lion's share (95%) of the fines was paid by Roche ($410 million) and BASF ($308 million). Rhone-Poulenc was granted amnesty for its participation in the vitamins A and E cartels, but its new parent Aventis was fined $4.5 million for its Hoechst subsidiary's collusion in D3. The amnesty provision was worth €217 million ($193 million) to Rhone-Poulenc. In addition, the participants in the vitamins B1, B6, biotin, and folic acid cartels were not fined because of the Commission's five-year "statute of limitations."[215] The time that elapsed between the date the investigation began and the date the violation ceased ranged from five years and two months to five years and five months. As a result of its slow start, the Commission levied no fines on five otherwise guilty firms: Lonza, Kongo, Sumitomo, Sumika, and Tanabe. Roche, BASF, Takeda, and five other firms benefited greatly from the five-year rule. The EC has been criticized for its tendency to delay the start of its investigations, which has allowed many cartel violators to escape punishment (Arlman 2005). The net reduction in fines from the EC's slowness to act benefited the 13 firms to the tune of €290 million ($257 million).

[209] It was not until June 4th and June 15th that the two companies sent memoranda to the EC admitting their violations. BASF supplied a bundle of documents on June 23, 1999. Both Roche and BASF are judged to be instigators, which would disqualify them for leniency in any case.

[210] By the time the EC's decision was adopted in November 2001, Rhone-Poulenc had merged with Hoechst to become Aventis (now named SANOFI Aventis). Aventis was granted a 100% reduction in fines for Rhone's violations but only 10% for Hoechst's cartel activities. Roche and BASF each received a 50% reduction.

[211] The EU has no authority to sanction individuals involved.

[212] Sumika is identified as an independent company, whereas most other sources indicate that Sumika is a controlled subsidiary of Sumitomo Chemical.

[213] Consistent with Bernheim's (2002a) analysis, at least one target firm admitted to "collusive contacts" in the 1980s that ended in 1989 when prices fell temporarily (EC 2001: endnote 21). Give the turnover among managers and unavailability of 15-year-old corporate records the lack of follow-up may be justified on pragmatic grounds.

[214] The decision contains a short paragraph that relates that the respondents (Roche and BASF) admitted discussions on fixing premix prices in Europe but that "…there had never been any effective agreements…since most sales were made as 'straights'" (EC 2001:¶129). Under a conspiracy theory of cartels, such an excuse would not be tolerated. Even as a matter of simple logic it is suspect. A separate decision on choline chloride is discussed below.

[215] Technically this is not a parliamentary act, rather, the rule is contained in Article 1 of the European Council's Regulation (EC) No. 2988/74 and Article 25 of Regulation No. 1/2003.

Choline Chloride (Vitamin B4)

The European branch of the global choline chloride cartel was investigated and fined by the Commission for slightly more than five and one-half years: from May 26, 1999 to December 9, 2004 (EC 2004).[216] After completing its investigation, the EC intended to fine all six members of the global conspiracy, but again was foiled by its procrastination and the five-year "statute of limitations." In this instance, the EC seems to have blundered badly by not opening its investigation earlier. Even if the DOJ did not share the fact that Bio-Products had been approved for amnesty in June 1998, the EC must have been aware of Chinook's well publicized guilty plea in September 1999. Even more unsettling is the EC's own admission that Chinook's legal counsel met with the Commission a month later and that the company delivered considerable written information about the choline chloride cartel in December 1999 (EC 2004:17). Yet, the Commission inexplicably declined to investigate what must have been clear evidence of a global cartel with effects spilling over into the EU market.[217] Instead, the EC waited until late May 1999 to formally open its probe in response to a formal application of leniency from Bio-Products on April 28, 1999 (*ibid.*).[218]

From the EC's point of view, the choline chloride cartels operated at "two levels," a group of three sellers within the EU and a global organization of six firms (EC 2004: 21). UCB and Akzo argued that the global and European arrangements were separate infringements (*ibid.*). Yet, from a legal point of view the EC ruled that the multiple branches or levels constituted a "single and continuous infringement" of the EU's competition rules (*ibid.*, pp.50-53). A ruling that there were two infringements would have favored the European firms, because the EC increases the fines for more durable cartels. The global group got started by November meeting in Germany in November 1992, whereas the European branch may not have begun anticompetitive discussions until March 1994. Price targets were discussed by the three European manufactures at its last meeting in Aachen, Germany in October 1998.

By contrast, the EC had no evidence of North American participation at price-fixing meetings after April 1994. This is the main factual basis for exculpating the North American conspirators. The EC's interpretation of the cessation of collusion by the North American producers is at odds with its view that there was only one collusive group. It is true that North American exports to Europe began soon after April 1994, but this is hardly conclusive evidence that some of a permanent, full, or irrevocable abandonment of the global agreement. Besides, there *were* collusive bilateral contacts between BASF and some American firms regarding Latin American sales (EC 2004:35). Moreover, Chinook and Bio-Products provided ample evidence of continuing successful collusion in the North American market. European buyers were harmed

[216] This 77-page decision was published in late 2005. It is the most complete source of information on the choline chloride market and the cartel's operations.

[217] The documents submitted by Chinook totaled 255 pages (EC 2004: footnote 38). It is not known whether they contained information on the European branch of the cartel, but it is known that Chinook and UCB had many meetings and other contacts throughout the cartel's existence. Moreover, Chinook's submissions did describe Chinook's admission that it attended illegal cartel meetings and the 1992 agreement that prevented the North American members of the global cartel from exporting to Europe.

[218] In letters sent July 1999 and October 1999, Chinook claimed that its November 1999 meeting with the Commission was in fact an application for leniency, and it disputed Bio-Product's right to qualify for amnesty (EC 2004: ¶52). The Commission replied in September 1999 that ",,,Chinook's legal counsel had insisted …on the provisional, exploratory and informal nature of the contacts." (*ibid.*). Memories of this meeting vary. When Bio-Product's counsel met with the Commission in April 1999, he specifically cited full cooperation under the 1996 Leniency Notice. It appears from this episode that it is necessary for counsel to specifically cite (perhaps in a proffer letter) the EC's Leniency Notice when applying for leniency. In this particular case the leniency decision was mooted by the EC's finding about the early ending date of the global-level conspiracy.

until at least September 1998, because absent the North American cartel geographic arbitrage on a much larger scale would have broken the European cartel.

The EU's choline chloride investigation lasted for 68 months. In the decision of December 9, 2004 the three European manufacturers of choline chloride were fined a total of €66.34 million or $88.4 million (EC 2004:60-75). BASF, the smallest of the three, received the largest fine of $36 million (Appendix Table 2A). The fines were calculated by starting at the minimum point for a "very serious" infringement (€20 million per firm), because the EU affected sales of $408 million were judged to be "relatively small." Then the Commission decided to create four firm-size categories based on the six companies' *global* market shares; as a result, the three European companies got fine reductions of 36 to 53%. Then, in the name of deterrence, the preliminary fines were raised by 100% for Akzo Nobel and 50% for BASF using the companies' 2003 global sales as a guide. A further increase of 55% was implemented for all three because of the cartel's 5.5 years' duration, and BASF received a further 50% enhancement for recidivism involving a 1994 EU decision. No attenuating circumstances, including leniency, were permitted to moderate the fines. The final adjustments were modest reductions of 20 to 30% for various degrees of investigative cooperation (timely delivery of evidence, degree of detail provided, or a decision not to contest the facts).

Four aspects of the EC's fining procedures appear to be arbitrary. The percentages applied for enhancements or reductions have evolved over time to become somewhat consistent across cases, but are nevertheless difficult to square with a deterrence framework. Relative to the harm caused in the EU market, BASF's fine ended up being three times harsher than Akzo's Appendix Table 2B). Singling out BASF for recidivism was also curious, because the other two firms were also recidivists. The reduction in fines because of the allegedly small size of the chlorine chloride market is difficult to accept; it was in fact the fifth largest of the nine vitamins cartels fined by the EU. Finally, the four market-share categories are arbitrary. Only two were used in the other vitamins cases; worse, the top two categories were populated by the North American targets that had already been eliminated from consideration.

Chinook, Bio-Products, and Nepera were not sanctioned simply because their active collusion was deemed to have ended more than five years before the EC's investigation began in May 1999.

Other Jurisdictions

Eight other nations[219] investigated the vitamins cartels, but only three of them punished members of the global vitamins cartels with fines. In the aggregate the fines were small (Table 17).

In March 2001, an Australian court approved fines recommended by the Australian Competition and Consumer Commission for three vitamin suppliers that admitted fixing prices of bulk vitamins A and E sold to animal-feed companies. The three Australian subsidiaries of Hoffmann-La Roche, BASF, and Rhône-Poulenc (now Aventis) agreed to pay penalties of Australian $26 million (US$14.3 million), a record amount under the country's 1974 Trade Practices Act. In fact, the A$15 million paid by the Roche subsidiary was more than double the previous record amount. The Commission Chairman stated that the settlement was a lenient one because of the defendants' cooperation in avoiding a costly trial. Price fixing allegations concerning human vitamins were under investigation in 2003, but not yet completed by early 2006.

[219] No information can be found about the French, Mexican, or Taiwanese investigations.

Another antitrust authority that imposed monetary sanctions in vitamins is the Korean Fair Trade Commission (KFTC 2003). Korea is totally dependent on imports for its bulk vitamins, so obtaining evidence was especially difficult in this case. In April 2003 the KFTC announced that it was demanding $3.1 million from six foreign manufacturers: Roche, BASF, Aventis, Eisai, Daiichi, and Solvay. Affected sales in Korea were $185 million. The KFTC gave one example of price changes caused by the cartel. Compared to the year before the cartel, import prices of vitamin B5 rose to a 1997 peak 70% above the base price.

Brazil opened an investigation of the vitamins cartels in 1999 that focused on the three largest companies and their three largest products (UNCTAD 2002:5-6). These three products achieved more than $500 million in affected sales. Through interviews with managers of the three companies' Brazilian subsidiaries, the Brazilian antitrust authority issued an adverse decision in December 2002. In 2005, a study by one of Brazil's antitrust authorities (the SDE) found that the Big Three members of the cartel had caused Brazilian import prices for the seven largest vitamin products to rise by $183 million (30 to 37%). The companies' appeals were still active in early 2006.

One of the more surprising developments concerned Swiss reactions to the vitamin cartel. In early May 2000, the Swiss competition-law agency WEKO came to the fairly obvious conclusion that the global vitamin cartel had affected vitamin prices in Switzerland. Therefore, WEKO issued an injunction against its national champion Hoffmann-La Roche and its co-conspirators to cease price fixing. This is in fact the maximum sanction WEKO could impose for a first-time price fixer. Only if Roche or its co-conspirators *repeat* their crime can they be fined under current Swiss law. With the weakness of Swiss sanctions so fully revealed to the world, to avoid the appearance of a cover-up for Roche both houses of the Swiss parliament passed motions in late May supporting the imposition of fines for first-time offenders. Swiss competition law is now aligned more closely with that of the EU Member States.

Among the jurisdictions with well established antitrust laws, Japan is notable for the near absence official actions taken publicly against foreign conspirators in international cartels; nor has it punished admittedly guilty domestic cartelists, namely, the two lysine or six vitamins companies headquartered in Japan. The two Japanese lysine companies (Ajinomoto and Kyowa Hakko) issued press releases apologizing for their actions, but did not immediately fire any of its employees involved in price fixing. After raiding the offices of ten vitamin manufacturers in January 2000, the Japan Fair Trade Commission (JFTC) found no evidence of cartel behavior by any of the European producers. However, three of the largest Japanese vitamin manufacturers imposed a number of sanctions upon themselves immediately after their guilty pleas in the United States. The presidents and all board members of the three companies voluntarily took fairly significant pay cuts; their presidents resigned from honorary positions in various Japanese trade associations. In April 2001, the JFTC issued warnings against Daiichi and Eisai for their collusive activities in the markets for vitamins B5 and E.

New Zealand took similar action. In January 2001 the Commerce Commission sent warnings to the local subsidiaries of Roche, BASF, and Aventis. A statement by the Commission said that bringing charges was not possible because the last New Zealand meeting about prices occurred in 1994, and the Commerce Act has a three-year statute of limitations.

Private Suits

United States of America

Private treble damages suits filed in the United States resulted in the largest antitrust settlements in history. Scores of class actions were filed in many federal courts around the

United Sates, and these were consolidated in one principal action[220] that was argued in the U.S. District Court for the District of Columbia in 1999 to 2003. This consolidated suit had approximately 4,000 plaintiffs, firms that had purchased bulk vitamins in the United States directly from the major manufacturers. Most were manufacturers of animal feeds, foods, pharmaceuticals, or vitamin premixes; some were farmers or farm cooperatives; and some were chemical wholesalers. Not all eligible buyers registered as plaintiffs.[221]

Chief Judge Thomas Hogan was in charge of ruling on dozens of issues that came before the Court. One decision he made was to split off the main suit and create three other groups with somewhat different issues: the niacin and biotin group (with defendants Lonza, Degussa, Nepera, Reilly, Sumitomo, and Tanabe), the choline chloride group (BASF, Akzo Nobel, Chinook, Bio-Products-Mitsui, DuCoa, and UCB), and E Merck.

Each of the defendants had retained a couple of law firms, and the federal class was represented by scores of law firms. At least 500 lawyers feasted on fees that would top $250 million (Boies 2004:254). In May 1999 plaintiffs' firms chose three among them to act as co-lead counsel, including a well known litigator, David Boies II (Donovan 2005). His firm had been collecting exculpatory, if mostly circumstantial evidence for more than a year and had been one of the first to file a complaint. Boies (2004) relates that Roche first offered to settle in December 1998, five months before their guilty pleas were announced. He also claims that he offered the Big Three a settlement offer of $400 million in April 1999, but at the meeting of plaintiffs' firms one month later he was told to settle for a minimum of $550 million. Roche and BASF were eager to accept, but Rhone-Poulenc was unwilling to pay at the same rate as the other two. A settlement agreement with the Big Three defendants was reached in about six months, very quickly compared to most large treble damages cases. With the last-minute addition of the three largest Japanese defendants, Boies presented a preliminary agreement for $1.17 billion to Judge Hogan on November 3, 1999. Fees of $123 million were added later.[222] The proposed settlement was hailed by many as the largest antitrust class-action sum in history. Later, Boies and company were able to obtain a further $225 million from the 12 smaller, but recalcitrant defendants.

Boies' (2004) inside account of the settlements reveals that the lead counsel of the federal class aimed at extracting at most single damages from the vitamins defendants (p. 250). However, the settlement amount was only about 18% of direct purchases of bulk vitamins and 51% of estimated overcharges.[223] Several of the largest buyers were dissatisfied with the amount negotiated by class counsel, partly because they believed that the overcharges were at least twice as high as represented by class counsel. Thus, in March 2000 about 300 companies formerly in the federal class decided to opt out of the main settlement. They then filed separate law suits (often called "direct actions") to recover treble damages.

[220] *In re Vitamins Antitrust Litigation* dealt with the Big Six defendants and their products. Prosecution of the "Little Twelve" and some of the smallest products (vitamins B3, B4, B9, and H) proceeded on separate tracks.

[221] One can only speculate on the motives of buyers that failed to join the class action. Some failed to hear of it, some kept no records of purchasers, and some were too small to be bothered. Perhaps some were reluctant to endanger their business relationships with the defendants. Possibly defendants made restitution to some customers prior to litigation.

[222] These fees, as a share of the anticipated $1.17 billion, would have been a low 10.5%; adding the additional $225 million, the ratio would have been 8.8%. However, the reduced payout to the rump class after the opt-outs fled raised the fee rate to above 50%.

[223] Less than six months is insufficient time to obtain the type of data under discovery that would have allowed accurate economic estimates of the overcharges. Moreover, the initial settlement did not allow for price fixing that may have occurred in the 1980s. Class counsel claimed that the settlement was 23% of sales (Boies 2004:254).

Direct-action plaintiff's lawyers pressed the defendants to get as much information as possible to prosecute their claims. Most of the details about the scope of discovery requests are confidential and must be inferred from expert's reports that have come to light. Defendants' ended up divulging a great deal of financial and economic information to the plaintiffs (Bernheim 2002a, 2002b). Hundreds of thousands of transactions of vitamins products were revealed. Monthly prices from as far back as 1980 and as recently as 2001 were made available for scores of specific grades of bulk vitamins; these dates extended far beyond the longest guilty-plea periods. Internal data on plant locations, production capacities, quantity of output, input costs, and sales to various locations were given to plaintiffs for the purpose of expert analyses.[224] Scores of depositions were taken. From the time that plaintiffs' law firms first met to organize, three years elapsed until their expert's analysis was prepared.

In motions made to Judge Hogan, plaintiffs also attempted to obtain relevant records of written submissions by the defendants to the Canadian and EU antitrust authorities (Spratling and Arp 2005: 39-40). One set of documents were the amnesty applications made by some of the defendants. Both the Canadian and EU governments opposed turning over these documents. Judge Hogan ruled that the European Commission must provide the submissions, but the Canadian government did not. As a result of these and other discovery motions, Canada and the EU amended their leniency-program rules to permit entirely *oral* leniency applications and witness interviews.[225] These policies are consistent with U.S. practice.

Although only about 3% of the number of plaintiffs, the direct-action plaintiffs represented 75% of all plaintiffs' bulk vitamin purchases during the conspiracies of the 1990s (Denger 2005). Thus, the opt-outs were generally much larger buyers than those remaining in the federal class after March 2000. Most of these opt-outs were represented by Kenneth Adams, who later outlined the terms of their settlement (Greene 2005). He asserted that his clients received a settlement of almost $2 billion. Thus, as a percentage of their nominal purchases in the 1990s the opt-out firms' settlement was about 77%.[226] This compares to the 15 to 18% received by the buyers who stayed in the federal class. That is, Adams' clients recovered *five times* as much per dollar purchased than the remaining members of the class.[227] Denger (2005:7) extrapolates these data to all the opt-outs and suggests a recovery of $3.5 to $4.5 billion.[228] Together with the recovery and fees of the federal class (mentioned above), direct purchasers were paid $4.0 to $5.0 billion.

[224] Bernheim (2002: xxi-xxii) calculates that all plaintiffs incurred overcharges of $2.103 billion in current dollars (3.507 billion in damages converted to 2002 dollars). Of that total, 47% was imposed on the direct-action plaintiffs and 53% on the remaining federal class. In addition, during the possible 1985-1989 collusive episodes damages for the opt-outs amounted to a further $209 million (2002 dollars) or an additional 21%; because of the greater lapse of time from the 1980's episode, the damages were an additional $465 million (in 2002 dollars) or 28%. Class plaintiffs made no claims of damages from collusion in the 1980s.

[225] Officially, the EC prefers written submissions by companies applying for leniency (Spratling and Arp 2005:40-41). The oral applications are transcribed by the EC and are reviewed and certified by counsel for the applicant. The EC maintains that these transcripts are Commission documents, not company documents, and are hence not discoverable by U.S. litigants. The discoverability of "paperless" leniency applications is still in doubt.

[226] However, as a percentage of nominal dollar purchases for the *extended* 1985-1999 conspiracy period, the opt-outs recouped only 61%. Moreover, it is proper to compare the $2 billion to the present value of the affected commerce of the cartels, which would further lower the percentage.

[227] One of the largest opt-outs was Tyson Foods. In fiscal years 2002-2004 the company's distributions from various settlements were so large ($306 million) that they had to be reported in their annual stockholders' reports. Similarly, arch price fixer ADM reported distributions of $175 million.

[228] Denger hints that the remaining opt-outs got from three to five times what they would have received ($350 million) had they remained in the federal class. This follows from his statement that the recovery of direct buyers from the Big Six defendants alone was $3 to $4 billion and the known $225 million from the

Although Boies and the other class counsel may be open to criticism for negotiating a sweetheart deal without full information with the Big Six, they worked much harder during 2000-2004 in pursuing many of the Little Twelve remaining defendants. Except for two financially weak firms in the vitamin B4 cartels, plaintiffs obtained much higher settlement per dollar of sales by exploiting the legal rule of joint and several liability (Boies 2004: 255-260). Although some of these figures may be exaggerated, Boies asserts that the four vitamin B3 suppliers paid out 63% of their U.S. cartel sales.; that in 2002 Sumitomo agreed to an amount equal to 82% of its cartel revenues; and that E. Merck's $50-million settlement was 89% of the company's affected sales. The most lucrative victory for the vitamins plaintiffs was in a jury trial that was held because Mitsui refused to admit that it had managerial control over its 100%-owned subsidiary, vitamin B4 producer Bio-Products. With strong economic testimony by the plaintiffs' expert and a poor showing by Mitsui's legal team, the jury decided that Mitsui owed trebled damages of $114 million.[229]

Indirect buyers received relatively little compensation. The biggest settlement was prosecuted by the National Association of Attorneys General. The $305 million they recovered was the largest such suit in U.S. history. This settlement was distributed to commercial indirect purchasers, consumers, and more than 40 states as direct buyers. A few other indirect-purchaser recoveries are known.

Canada, Australia, and the United Kingdom

The most successful private suits were launched in Canada, which has had a law authorizing class actions for single damages since 1992. Canadian courts began authorizing substantial recoveries in the late 1990s. The vitamins litigation was settled in the Supreme Court of British Columbia in April 2005 (for BC residents only) and in Ontario Superior Court (for the rest of Canada) in March 2005.[230] There were 20 corporate defendants. Unlike the United States, the courts consider three groups of plaintiffs simultaneously: direct buyers, indirect commercial buyers, and consumers. Including fees, the vitamins settlement aggregated to C$127 ($US 105) million on total Canadian affected sales of C$870 million (14.5%).[231] The settlement was by far the largest private antitrust suit in Canadian legal history. Approximately 75% of the funds were distributed to direct buyers and 17% to indirect buyers; the latter was handled through a *cy pres* process by giving the funds to selected consumer and trade associations. The settlement amount was strongly affected by an analysis of a University of British Columbia economist that concluded that Canadian overcharges were12 to 16% of affected sales.

In Australia, a class action was filed in 1999 against the three largest vitamin makers on behalf of buyers of eight animal-grade bulk vitamins. In late 2004 class counsel and the defendants were still at an impasse. As of early 2006 no news was available about a settlement or court proceeding.

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smaller defendants. Legal and experts' fees exceeded $250 million. To allow for the possibility that Denger does not include vitamins B3, B4, and other small vitamins markets, I raise the upper end of the range of known and unreported, direct and indirect U.S. settlements to $5.7 billion.

[229] Plaintiffs had masterfully been able to get the three members of the EU branch of the B4 cartels to settle for $22 million, but they estimated that trebled damages were $135 million. Thus the jury gave the buyers everything they had asked ($135 minus $22 million). Prior to trial, Mitsui could have settled for the remaining *single* damages of $25 million. After the verdict, to avoid the uncertainty of an appeal, the plaintiffs agreed to a $53-million payment.

[230] Although these decisions include methionine, the text covers vitamins only and excludes post-judgment interest.

[231] The affected sales when measured at prevailing exchange rates in the 1990s is closer to $US 546 million

An important private antitrust case captioned *Provimi v. Roche Products* came before the English High Court (Olsen 2005). Provimi is part of a German company that purchased bulk vitamins in Germany and the UK, and Roche Products is a UK subsidiary of Roche Holdings of Switzerland. In its 2003 ruling the high court permitted the plaintiff to seek compensation for damages on its German purchases in a UK court on the theory that Roche Products' conduct in the UK implemented the cartel throughout Europe. This preliminary decision[232] might make UK courts the fora of choice for European victims of international cartels, so long as the buyer has some connection with the UK (Joshua 2005). The UK has liberal discovery rules that favor plaintiffs in cartel cases.

Sanctions Summary

Global sanctions levied on the corporate participants in the vast vitamins cartels of the 1990s are shown in Table 18. The total outlays in the six years following their discovery in 1999 by U.S. prosecutors were in the range of $6.2 to $7.6 billion. Government fines, originating almost entirely from three jurisdictions, accounted for 25% to 30% of the total. Estimated settlements by direct buyers in the United States comprised the biggest category of penalties, 65 to 75% of the total. The remaining types of sanctions are relatively minor: indirect purchaser suits in North America (7 to 8%) and non-U.S. private suits (1%). Expressed in 2005 dollars and adjusted for inflation and the absence of prejudgment interest, the monetary sanctions are quite a bit lower (Table 18A). Real sanctions in 2005 dollars are slightly less than half the penalties computed in nominal dollars.

Not shown are the individual criminal convictions 17 high ranking executives of these companies. In the United States, 16 men were sentenced to pay fines that averaged about $200,000. When evaluating the force of expected sanctions on cartel deterrence, it is difficult to know how to weight the impact of expected individual prison sentences as compared to corporate penalties.

[232] The parties settled out of court for an unknown amount before an appeal could be argued.

Table 18. Summary of Corporate Fines and Settlements, Vitamins Cartels, 1999-2006			
Type of Sanction	Known	Estimated	Total
	Millions nominal U.S. dollars [a]		
Government fines:			
United States	915.2	--	915
European Union	847.3	--	847
Canada	82.3	--	82
Australia	13.7 [e]	--	14
Korea	3.1	--	3
Brazil	8.7	--	9
Other countries [b]	--	0	0
Subtotal fines	1870.3	0	1870
Direct buyers:			
U.S., major vitamins [c]	365	3054-4404	3419-4769
U.S., E. Merck	51	--	51
U.S., niacin & biotin group	157-161	--	159
U.S., choline chloride group [d]	74.5	--	75
Canada, all products	95 [f]	--	95
Australia [g]	31	--	31
Subtotal Direct Purchasers	742.5-746.5	3095-4445	3831-5181
Indirect buyers:			
Nat'l. Assn. of Attorney's Gen.	305	--	305
California	96	--	96
Massachusetts	19.6	--	20
Other United States	--	75-100 [e]	88
Canada	20 [f]	--	20
Subtotal Indirect Purchasers	440.6	75-100	516-541
Total	3053.4-3056.5	3134-4514	6217-7593

--= Unknown or not applicable
Sources: Press releases of antitrust authorities, press reports, law firms' web sites, Appendix Tables 2 and 10, Denger (2005), and Boies (2004).
[a] Fines and settlements outside the United States are translated into U.S. dollars on the date of announcement. Includes legal fees of plaintiffs' counsel where known.
[b] Investigations are reportedly still underway in 2005 by Brazil. Mexico's fines unknown.
[c] Follows from a November 1999 agreement between about 4,000 plaintiffs in a federal class action and the seven largest defendants. Some of the settlements are secret and are estimated, others were publicly reported.
[d] Includes $21.5 million in civil settlements by BASF, Akzo Nobel, and UCB Chemicals
[e] Estimated
f) Canada combines direct (81% of the settlement) and indirect (19%) purchasers into unified legal actions; includes fees.
g) Settled July 2006; includes plaintiffs' fees.

Table 18A. Summary of Real Corporate Fines and Settlements, Vitamins Cartels, 1999-2006			
Type of Sanction	Known	Estimated	Total
	Millions of 2005 U.S. dollars [a]		
Government fines:			
United States	445	0	445
European Union	384	0	384
Canada	39.7	0	40
Australia	6.4	0	6
Korea	1.6	0	2
Other countries [b]	0	0	0
Subtotal fines	876.7	0	877
Direct buyers:	354	1471-2113	1825-2467
Indirect buyers:	210	36-48	246-258
Total	1441	1507-2161	2948-3602

Sources: Tables 17A and 18 and producer price indexes and prime rates of interest.
[a] Fines and settlements outside the United States are translated into U.S. dollars on the date of announcement. Includes legal fees where known. Some of the conversions of settlements into real 2005 dollars are approximate.
[b] Investigations are reportedly still underway in 2005 by Brazil. Mexico's fines unknown.
[c] Follows from a November 1999 agreement between about 4,000 plaintiffs in a federal class action and the seven largest defendants. Some of the settlements are secret and are estimated, others were publicly reported.
[d] Includes $21.5 million in civil settlements by BASF, Akzo Nobel, and UCB Chemicals
[e] Estimated
f) Canada combines direct and indirect purchasers into unified legal actions; includes fees.
g) Settlement July 2006; includes legal fees.

Assessing the Sanctions

How heavy were the fines and settlements? To answer that, the monetary sanctions are compared first to the value of affected commerce (Tables 19 and 19A) and second to the overcharges (Tables 20 and 20A). Both nominal dollars and real dollars are employed. Fines, sales, and overcharges are estimated for each combination of cartelized product and region, but the reliability of these ratios vary across markets (see box).

Table 19. Global Monetary Sanctions Relative to Affected Sales

Product Market	United States			Other Jurisdictions			World
	Govt.	Private	Total	Canada [a]	EU	Other	
	Percent of nominal U.S. dollars						
Beta carotene	15.7	50.0	65.7	17.1	14.2	0	29.9
Canthaxanthin	0	7.9	7.9	0	16.0	0	5.1
Biotin (vitamin H)	0	66.1	66.1	10.0	0	0	21.7
Choline chloride (B4)	1.2	20.1	21.3	4.0	24.4	0	12.5
Folic Acid (B9)	0	139.4	139.4	0	0	0	139.4
Vitamin A	12.1	50.6	62.7	15.4	8.4	1.1	24.5
Vitamin B1	0	97.8	97.8	0	0	0	20.0
Vitamin B2	24.6	66.1	90.7	16.5	30.0	0	40.8
Vitamin B3	11.6	22.6	34.2	28.0	0	0	16.7
Vitamin B5	22.0	51.8	73.8	29.5	37.5	.2	48.1
Vitamin B6	0	80.3	80.3	0	0	0	80.3
Vitamin B12	0	8.1	8.1	237.5	0	0	3.2
Vitamin C	19.6	53.7	73.3	19.2	11.6	0.8	32.5
Vitamin D3	0	0	0	0	38.7	0	15.8
Vitamin E	15.8	55.6	71.4	15.5	8.9	0.8	32.3
Premixes	21.4	62.4	83.8	32.5	0	0	26.7
Total	12.0	61.7	73.7	15.0	8.3	0.2	25.9

Sources: Appendix Tables 1 and 2.
Note: U.S. and Canadian fines and settlements are in most cases allocated across markets using the market shares of the defendants. For estimated ranges, the mid point is used. Nominal U.S. dollars are used, which causes the ratios to be overstated.
a) Includes 2005 private settlements for single damages to direct and indirect purchasers that account for 51% of the total.

Table 19A. Real Global Monetary Sanctions Relative to Real Affected Sales							
Product Market	United States			Other Jurisdictions			World
	Govt.	Private [a]	Total	Canada [b]	EU	Other	
	Percent of 2005 U.S. dollars						
Beta carotene	7.5	36.0	43.5	7.0	6.6	0.0	22.3
Canthaxanthin	0.5	3.5	4.0	0.0	7.5	0.0	2.9
Biotin (vitamin H)	0.0	28.2	28.2	0.0	0.0	0.0	9.9
Choline chloride (B4)	0.4	10.4	10.8	1.3	7.0	0.0	6.3
Folic Acid (B9)	0.0	64.9	64.9	0.0	0.0	0.0	22.9
Vitamin A	5.0	32.7	37.7	5.8	3.2	0.4	15.2
Vitamin B1	0.0	33.0	33.0	0.0	0.0	0.0	8.1
Vitamin B2	7.6	31.2	38.8	4.9	9.7	0.0	20.5
Vitamin B3	4.7	13.2	17.9	5.7	0.0	0.0	8.1
Vitamin B5	8.4	32.0	40.4	9.2	13.5	0.1	24.9
Vitamin B6	0.0	31.5	31.5	0.0	0.0	0.0	8.1
Vitamin B12	0.0	3.1	3.1	48.1	0.0	0.0	1.3
Vitamin C	5.8	24.0	29.8	5.7	3.0	0.1	12.0
Vitamin D3	0.0	0.0	0	0.0	18.0	0.0	9.2
Vitamin E	6.7	35.5	42.2	6.0	3.5	0.3	21.0
Premixes	4.5	24.2	28.7	8.2	0.0	0.0	10.0
Total	4.9	26.6	31.5	5.9	3.3	0.1	10.7

Sources: Table 17B and Appendix Table 1B.
Note: U.S. and Canadian fines and settlements are in most cases allocated across markets using the market shares of the defendants. For estimated ranges, the mid point is used. Nominal U.S. dollars are used, which causes the ratios to be overstated.
a) Includes Canada.
b) Excludes 2005 private settlements for single damages to direct and indirect purchasers that account for a slightly higher amount than the fines.

DATA QUALITY

The data used to construct the ratios in Tables 19 and 20 vary in their completeness, precision, and reliability.

The numerators (amounts of **fines** or **settlements**) are generally fairly precise and reliable, especially for EU fines. U.S. and Canadian fines are also precise for individual firms, but the company fines for some products had to be distributed across the relevant products in proportion to affected sales in each jurisdiction (Appendix Table 12). Given the fining policies in North America, this is a reasonable procedure, but a step that may degrade precision. All non-U.S. fines and affected sales were translated into U.S. dollars on the date the fines were levied or averaged across the collusive dates, respectively.

Affected sales by industry for the United States and the world were taken from the most reliable internal source, namely, the Data Books kept by Hoffmann-La Roche (Bernstein 2002a). These numbers were cross-checked for accuracy against the sales records of other defendants and direct buyers. Canadian sales were mostly derived from a spreadsheet posted on the Canadian Competition Bureau's web site. EC (2001, 2004) gave affected commerce in Western Europe for most years of the cartels; a few earlier years were estimated by backward projection. Sales in the rest of the world are the least reliable because they are residual amounts. For affected sales by firm and product, market shares were used to distribute industry sales; world production shares are slightly more accurate than the sales shares available for the United States, Canada, and EU. Uncertain estimates are signaled by showing a range rather than a point estimate (Appendix Table 1).

Overcharge rates by market are the most accurate for the U.S. market because several methods were applied to verify the percentages (Table 14). The Canadian rates were assumed to be the same as in the United States. Overcharges in the EU are somewhat more approximate because they were calculated from EC price series using only the before-and-after method (Appendix Tables 3 and 4). The rest of the world relies on a combination of the U.S. and EU numbers. Global price effects are a weighted average of the regional rates. To prepare firm-level overcharges in Appendix Table 13, the total overcharge for each region and product was distributed across each participant according to its share of the region's market. That is, because all members of a cartel in a given region charged very similar prices, they are assumed to have the same percentage overcharge. Because production cost may vary, the firm-level overcharges are somewhat less accurate than the more aggregated figures.

Penalties Relative to Affected Sales

Each product in Table 19 was the subject of either government fines or a settlement. There are 14 bulk vitamins that were fined by at least two of the three most active antitrust authorities; U.S. plaintiffs received payouts for 14 products. The absence of sanctions shows up as a zero in Table 19, and there are four products listed as cartels where no authority fined a company for price fixing (B1, B6, folic acid, and biotin). The reason these four were skipped by the authorities appears to be because of their small size or because a statute of limitations prevented prosecution. The mean affected sales of the four is $55 million in the United States and $80 million in the EU, and the mean overcharge is less than $20 million. Vitamin D3 is similarly small. For these reasons, all 16 cartels are listed in Table 19.

Measured in nominal dollars, total monetary sanctions averaged about 26% of global affected sales. The harshest fines were levied by Canada (15% of Canadian sales) with the United States slightly smaller (12%) and the EU the smallest of the three (8%). As a percentage of affected commerce in the rest of the world, fines by Australia, Brazil and Korea are

negligible.[233] By far the most intense sanctions are those extracted by private treble damages suits in the United States. When combined with U.S. fines, the vitamins defendants paid penalties equal to 76% of their U.S. revenues during the cartel periods. Canada's sanctions are not far behind with a combined government-private-penalty ratio of 34% of affected sales. Relative to affected commerce in their jurisdictions, North American monetary sanctions are *nine* times higher than the EU's. Therefore, the United States lives up to its reputation as the most fearsome antitrust jurisdiction.

Within jurisdictions but across products the sanctions/sales ratios have their lowest variation in Canada. Most markets fall in the 20% to 40% range. This pattern reflects a policy of starting with standard fines of 20% of Canadian affected sales for most members of a cartel and granting modest fine discounts for early pleaders or enhancements for late pleaders (Low 2005); compensation for single damages is also proportional to Canadian sales. With the notable exception of choline chloride, where ability to pay was a factor, U.S. fines are also a fairly steady share of affected commerce across the product markets, mostly 10% to 20% of affected sales. The EU displays much more variability across vitamins products. This is to be expected because the EU's starting fines are rather arbitrary, because its fining policies are not tied to affected sales in the jurisdiction, and because its numerous adjustments are also unrelated to EU sales.[234] There is a clear inverse relationship between the absolute size of a market's sales and the EU's cartel fines. Vitamins A, E, and C were the largest cartelized markets, but violators paid markedly lower EU fines.

There is an interesting connection between U.S. fines and the intensity of private settlements. Most private antitrust suits are follow-on actions. With guilty pleas made, private plaintiffs need not prove the fact of illegal collusion; they have the burden only of proving the extent of damages. Because the DOJ chose not to prosecute some of the cartels for reasons of administrative convenience, private litigants seem to have had a more difficult time extracting substantial settlements in the markets for vitamin B12 and other carotinoids.[235] Indeed, absent U.S. government prosecutions, U.S. buyers did not sue the vitamin D3 makers. On the other hand, private plaintiffs obtained relatively large settlements in the markets for vitamins B1, B4, B6, folic acid, and biotin – all markets with no or spotty U.S. prosecutions. Even companies that were not fined anywhere in the world (Sumitomo, Tanabe, Kongo, etc.) paid significant civil penalties in the United States and Canada. Moreover, the three European makers of chlorine chloride, which by restraining exports to North America were mostly passive supporters of the cartel, incurred substantial U.S. private penalties.

The penalty/sales ratios shown in Table 19 are frequently discussed in the antitrust law literature, but such a calculation is flawed. Government fines are imposed many years later than the cartel revenues were made; the average lag between the middle of a conspiracy and DOJ fines is about five years; and for civil cases and fines in the EU the lag averages about eight years. Because courts do not award prejudgment interest, the numerator is overstated compared to the sales dominator. When both the penalties and affected commerce are expressed in more appropriate real 2005 dollars, the harshness of the penalties is moderated considerably (Table 19A). On average the real ratios are *59% lower* than the unadjusted ratios. For the slower legal processes -- EU fines and private North American suits -- the properly calculated penalty/sales ratios are less than half the size of the conventional (nominal) ratios.

[233] Fines as a proportion of affected sales *within* Korea were less than 2%.

[234] In late 2006, the EC will implement new guidelines that in effect give EU affected sales greater weight in setting cartel fines.

[235] In the vitamins B3 and B4 cases, ability to pay hampered plaintiffs' efforts to collect settlements.

Penalties Relative to Injury

Another way of assessing the harshness of monetary sanctions is to divide them by the overcharges imposed by the cartels (Table 20). From the point of view of deterrence, these ratios are far more meaningful than the more common sanctions/sales ratios. As the overcharges are close to the amount of illegal profits garnered by the members of the cartels, the sanctions/overcharge ratios are indicative of the degree to which antitrust sanctions were successful in disgorging those profits. A ratio of 100% or slightly higher[236] means that all of a cartel's monopoly profits were transferred from the defendants to taxpayers or purchasers. Ratios higher than 100% imply that sanctions contained a punitive element, an outcome expected by law from U.S. treble damage suits. Low ratios indicate that members of a cartel as a group retained a significant portion of their collusive profits in a particular jurisdiction.

In current terms, global monetary sanctions from government and private legal actions amounted to 90% of the vitamins cartels' economic injuries. Canadian government fines were the highest (about 50% of Canadian injuries), whereas U.S, and Canadian fines fell below the Canadian level at 40% and 30%, respectively. The private damages suits in the United States were by far the harshest antitrust remedy. Private litigants received full compensation for all but four of the 16 overpriced vitamins. A punitive element is in evidence in the settlements of most of the products. When combined with the U.S. Government's fines, total U.S. sanctions were on average about 2.7 times the injuries of direct buyers.[237]

There is considerable variability in government sanctions/overcharges ratios across products in all jurisdictions. This is to be expected in Canada and Europe because the United States is the only antitrust regime that bases its maximum fines directly on the harm (when corporate fines exceeded $10 million). The majority of the vitamins defendants *were* fined under the double-the-harm rule. Yet, no U.S. fine comes close to 200% permitted by law, largely because of the granting of generous leniency discounts. Together with the settlements in follow-on private actions, double-damages or higher were recouped in about 12 of the 16 cartels. On the other hand, about half of the U.S. sanctions fell short of treble damages. U.S. sanctions were especially low for the following products: canthaxanthin, choline chloride, and vitamins B12 and D3. In several cases the low rates are connected to the absence of fines by U.S. courts. Without previous criminal guilty pleas, private plaintiffs lack the kind of *prima facie* evidence necessary to prevail in court. For choline chloride the issue for two of the three defendants was ability to pay.

The absence of private antitrust litigation in Europe is a major factor explaining the very low sanctions/overcharge ratios in Europe. Total public and private cartel penalties in Canada were about three times as severe as in the EU; U.S. penalties were *eight times* heavier than those in Europe. But in the rest of the world, the near absence of penalties of any kind brings the world-wide sanctions/overcharge ratios to clearly sub optimal levels for deterrence purposes. The vitamins defendants paid out at most 90% of their illegal gains to governments or victims.

Taking into consideration prejudgment interest and the probability of detection, world-wide sanctions were woefully short of optimally deterring defendants like those in the vitamins cartels (Table 20A). Because the penalties and overcharges are from different time periods, it is

[236] Vitamins sanctions were paid from one to four years after the collusion ended and as long as 20 years after the cartel began making monopoly profits. Thus, payments were made in significantly depreciated currencies compared to the vale of those currencies during the affected periods. For the most durable cartels, ratios of even 200% could be equivalent to purely non-punitive disgorgement. This issue is addressed below.

[237] The relatively small payouts to indirect buyers are included in the sanctions numerator.

appropriate to calculate the fines and overcharges in real dollars. In general, the numerators fall (real penalties are lower than nominal), whereas the denominators rise (overcharges imposed in the mid 1990s are smaller numbers than the overcharges expressed in 2005 money). On average, the real-dollar ratios are one-third of the nominal-dollar ratios.

Real penalties in the United States average well under 100% of real U.S. overcharges (Table 20A). World-wide, when measured in 2005 dollars, less than one-third of all damages were recovered from the vitamins cartels. Yet, the chances that secret cartels will be unmasked and penalized are less than 33%. There is no reason to believe that would-be cartelists are unaware of these ratios and probabilities of being caught. Thus, it follows that for *global penalties to be optimal, they must rise to at least nine times higher than they were in 1998-2005*. Even if U.S.-style antitrust enforcement were found everywhere in the world, the majority of international cartels will not be deterred from starting up.

Table 20. Global Monetary Sanctions Relative to Overcharges, 1999-2005

Product Market	United States			Other Jurisdictions			
	Govt.	Private [a]	Total	Canada	EU	Other	World
	Percent of nominal U.S. dollars [b]						
Beta carotene	51.3	246.5	297	47.7	46.0	0.0	39.0
Canthaxanthin	5.8	37.5	43	0.0	82.5	0.0	5.4
Biotin (vitamin H)	0.0	477.6	478	0.0	0.0	0.0	26.7
Choline chloride	3.5	89.8	93	11.9	64.1	0.0	17.0
Folic Acid (B9)	0.0	758.1	758?	0.0	0.0	0.0	61.8
Vitamin A	35.9	235.8	272	42.4	31.0	2.6	29.9
Vitamin B1	0.0	500.0	500?	0.0	0.0	0.0	21.8
Vitamin B2	88.3	361.1	449	60.0	126.1	0.0	45.1
Vitamin B3	71.1	204.5	276	91.3	0.0	0.0	15.5
Vitamin B5	69.1	244.7	324	72.1	107.5	0.4	50.7
Vitamin B6	0.0	322.3	322	0.0	0.0	0.0	21.8
Vitamin B12	0.0	21.4	21	292.3	0.0	0.0	3.2
Vitamin C	72.4	299.2	372	70.0	45.1	1.5	29.2
Vitamin D3	0.0	0.0	0	0.0	425.8	0.0	15.8
Vitamin E	40.8	217.7	249	36.7	25.0	1.7	41.4
Premixes	36.3	195.6	432	70.8	0.0	0.0	20.6
Total	40.0	231.9	271.9	49.6	30.3	0.7	90.0

Sources: Tables 14 and 17.
? = Questionable estimate, possible due to market-share allocation method.
Note: U.S. and Canadian fines and settlements are in most cases allocated across markets using the market shares of the defendants.
a) Includes private settlements in Canada.
b) Mid points of ranges shown in Table17.

Table 20A. Real Global Sanctions Relative to Real Overcharges, 1999-2005							
Product Market	United States			Other Jurisdictions			
	Govt.	Private [a]	Total	Canada	EU	Other	World [a]
	Percent of 2005 U.S. dollars [b]						
Beta carotene	21.2	101.3	122.5	19.7	14.5	0.0	44.6
Canthaxanthin	2.4	15.3	17.7	0.0	26.1	0.0	9.9
Biotin (vitamin H)	0.0	162.5	162.5	0.0	0.0	0.0	41.7
Choline chloride	0.6	15.6	16.2	2.1	9.4	0.0	9.2
Folic Acid (B9)	0.0	286.9	286.9	0.0	0.0	0.0	61.4
Vitamin A	12.2	80.0	92.2	14.4	8.1	1.0	30.9
Vitamin B1	0.0	181.4	181.4	0.0	0.0	0.0	58.3
Vitamin B2	24.4	100.0	124.4	16.6	26.7	0.0	50.3
Vitamin B3	24.2	68.1	92.3	23.2	0.0	0.0	37.3
Vitamin B5	16.1	61.5	77.6	24.5	28.0	0.1	42.5
Vitamin B6	0.0	130.6	130.6	0.0	0.0	0.0	24.4
Vitamin B12	0.0	7.0	7.0	68.2	0.0	0.0	2.6
Vitamin C	16.9	69.3	86.2	16.3	8.1	0.4	26.9
Vitamin D3	0.0	0.0	0	0.0	134.7	0.0	52.2
Vitamin E	13.9	73.6	87.5	12.5	6.5	0.6	33.6
Premixes	12.3	65.8	78.1	24.1	0.0	0.0	27.1
Total	12.4	66.6	79.0	15.3	8.4	0.25	28.4

Sources: Tables 14B and 17A.
? = Questionable estimates.
Note: U.S. and Canadian fines and settlements are in most cases allocated across markets using the market shares of the defendants. For estimated ranges, the mid point is used. Nominal U.S. dollars used.
a) Includes private settlements in Canada.
b) Mid points of ranges shown to left.

Intensity of Penalties Summarized

The intensity of 1998-2006 penalties in summarized in Tables 21 to 22A for three broad categories: government fines, direct-purchaser settlements and indirect-purchaser settlements. I first discuss the intensities in nominal term and second in real terms.

Government antitrust fines in all jurisdictions in nominal dollar terms amounted to 6.7% of the global affected commerce of the international vitamins cartels of the 1990s (Table 21).[238] The 7% figure is a combination of relatively high fines/sales ratios in North America, a medium fine intensity in the EU, and insignificant fines in the rest of the world. The range of intensities of private settlements across jurisdictions is similar but more pronounced.

Direct purchasers worldwide received compensation equal to 16.9% of the value of their purchases. However, nearly all of the vitamins payouts went to direct buyers in the United States and Canada. Economic theory suggests that indirect buyers should be burdened with at

[238] If the sales of the possible vitamins cartel episodes of the late 1980s were considered, all the ratios in Table 21 would be about one-fourth lower.

least half of and possibly all of the passed-on overcharge. Yet, *indirect purchasers* in the United States received compensation at a rate (6.7%) that was much lower than their counterparts farther up the vertical chain (54%). Except in North America, legal instruments to compensate final consumers and other indirectly injured buyers are completely undeveloped.[239] The upshot is that, measured in current dollars, the vitamins defendants disgorged about 26% of their cartel-period sales to citizens, taxpayers, and buyers of vitamins.

However, measured in more appropriate real dollars, global penalties were merely10.7% of global cartel revenues (Table 20A). The main reason that the sanction/sales ratio is lower in real dollars is that prejudgment interest is not paid by antitrust violators; additionally, violators reap illegal profits throughout the collusive period, yet even quickly levied sanctions are paid in depreciated currencies. Real fines in most jurisdictions are returned to the national treasuries and become in effect tax reductions or supplement government expenditures.[240] Private plaintiffs in North America recouped about 20% of the value of their purchases. Private suits in North America principally compensate direct buyers and indirect commercial buyers for their cartel-generated losses and pay plaintiffs' law firms for their costs and entrepreneurial risk.[241] Citizens and customer-victims of North America are being better served by their anticartel laws than are residents of the rest of the world.

The evidence on whether settlements from these private suits yielded punitive damages is addressed next.

Table 22 repeats the analysis in Table 21 but uses instead overcharges or monopoly profits as the metric. Recall that estimates of vitamins overcharges averaged a bit over one-third of affected sales (Table 15). Thus, the sanctions/overcharges ratios in Table 22 are on average three or four times larger than the ones in Table 21.

In terms of government fines, Canada, the United States, and the EU are again the jurisdictions with the harshest sanctions, ranging from roughly 30% to 50% of the overcharges in their regions. However, because the rest of the world levies miniscule fines on international cartels, total global fines recoup only 25% of the illegal vitamins profits.

Private treble-damages suits in the United States were remarkably effective in transferring vitamins damages back to the victims. Although slightly exaggerated because nominal dollars are the basis of these calculations, private U.S. actions for direct and indirect buyers amounted to about 200% of U.S. overcharges. The lion's share (89%) of private U.S. settlements goes to direct buyers. While not as high as the 300% specified by the Sherman Act, U.S. settlements do at least have a significant punitive component. In Canada, the 70% ratio is not a bad outcome for a relatively untested single-damages law. As in the United States, direct buyers were compensated to a far greater extent than indirect purchasers. Because economic theory implies that distributors and consumers pay the majority of cartel overcharges, this result suggests that the legal systems of North America are under-serving indirect buyers.

[239] Although not shown in Table 21, Canadian indirect buyers did get *cy pres* relief that was equal to about 4% of manufacturer-level affected sales or 1% of consumer-level sales.

[240] The United States has a unique program that distributes all federal corporate fines to the States to fund each State's program to compensate victims of violent crimes.

[241] Approximately 5% to 15% of most settlements as large as those in vitamins go to legal fees and costs of experts. Because the contingency-fee system is used for antitrust class actions in North America, plaintiffs' counsel finance the costs of prosecution for several years and are awarded risk premiums by the courts for the uncertainty of the outcomes.

Table 21. Summary of Fines and Settlements Relative to Affected Sales			
Type of Sanction	Known	Estimated	Total
	Percent of nominal U.S. dollars [a]		
Government fines:			
United States	12.1	0	12.1
Canada	15.1	0	15.1
European Union	8.2	0	8.2
Rest of the world	0.2	0	0.2
Subtotal fines	6.7	0	6.7
Direct buyers:			
United States	8.6	40-58	54.2
Canada	17.6 [b]	0	17.6
European Union	0	0	0
Rest of the world	0.4	0	0.4
Subtotal direct purchasers	2.8	11.6-16.7	16.9
Indirect buyers:			
United States	5.6	1.2	6.7
Rest of the world	0 [b]	0	0
Subtotal indirect purchases	1.7	0.3-0.4	2.0
Subtotal United States	26.3	29.0-35.9	73.0
Subtotal Canada	36.5	0	36.5
Subtotal European Union	8.2	0	8.2
Subtotal Rest of the world	0.6	0.1	0.3
Total all jurisdictions	11.2	11.8-17.0	25.9

Sources: Tables 18, 19 and Appendix Table 1. Includes a few sanctions not found in Table 19.
[a] Fines and settlements outside the United States are translated into U.S. dollars on the date of announcement. Includes legal fees where known. Some ratios use mid points of ranges.
b) About 18% of the Canadian settlement was distributed to non-profit organizations to benefit indirect commercial buyers and consumers.

Table 21A. Summary of Real Fines and Settlements Relative to Real Affected Sales

Type of Sanction	Known	Estimated	Total
	Percent of 2005 U.S. dollars [a]		
Government fines:			
United States	5.0	0	5.0
Canada	6.0	0	6.0
European Union	3.3	0	3.3
Rest of the world	0.1	0	0.1
Subtotal fines	2.9	0	2.9
Direct buyers:			
United States	2.9	16-23	22.9
Canada	9.3 [b]	0	9.3
European Union	0	0	0
Rest of the world	0.03	0	0.0
Subtotal direct purchasers	0.7	4.8-6.9	7.0
Indirect buyers:			
United States	2.2	0.4	2.6
Rest of the world	0.2 [b]	0	0.2
Subtotal indirect purchases	0.7	0.1	0.8
Subtotal United States	10.1	17-24	30.5
Subtotal Canada	17.6	0	17.6
Subtotal European Union	3.3	0	3.3
Subtotal Rest of the world	0.4	0	0.4
Total all jurisdictions	4.7	4.9-7.1	10.7

Sources: Table 18A and Appendix Table 1B. Includes a few smaller sanctions not found in Table 19.
[a] Fines and settlements outside the United States are translated into U.S. dollars on the date of announcement. Includes legal fees where known. Some ratios use mid points of ranges.
b) About 18% of the Canadian settlement was distributed to non-profit organizations to benefit indirect commercial buyers and consumers.

When the numerators and denominators are adjusted for the time value of money and for inflation, the ratios are markedly lower (Table 22A). Because of delays in imposing fines and the duration of the vitamins cartels, government fines in each of the jurisdictions recouped less than one-tenth of the real illegal profits. Delays in settling private suits in North America were even longer. Combined with the absence of prejudgment interest, the real-dollar vitamins settlements amounted to less than one-quarter of real damages in each jurisdictions, thus providing no punitive damages. Real global sanctions were only 11% of read harm. *No matter how high the probability of detection, no jurisdiction in the world is safe from cartel recidivism.*

Table 22. Summary of Fines and Settlements Relative to Overcharges, 1999-2000			
Type of Sanction	Known	Estimated	Total
	Percent of nominal U.S. dollars [a]		

Government fines:			
United States	39.8	0	39.8
Canada	49.9	0	49.9
European Union	30.3	0	30.3
Rest of the world	0.7	0	0.7
Total fines	24.6	0	24.6
Direct buyers:			
United States	28.3	133-192	178
Canada	58.2	0	58.2
European Union	0	0	0
Rest of the world	1.3	0	1.3
Total Direct purchasers	9.8-9.9	41-59	59.5
Indirect buyers:			
United States	18.3	3.3-4.3	22.1
Canada	12.1	0	12.1
Rest of the world	0	0	0
Total indirect purchasers	5.8	1.0-1.3	7.0
Subtotal United States	85.8	136-198	240
Subtotal Canada	120.2	0	120
Subtotal European Union	30.3	0	30.3
Subtotal Rest of the world	2.0	0	2.0
Total all jurisdictions	40.2	41-60	91.0

Sources: Tables 14 and 18. Includes a few sanctions not found in Table 19.
[a] Fines and settlements outside the United States are translated into U.S. dollars on the date of announcement. Includes legal fees where known. Some ratios use mid points of ranges.

Table 22A. Summary of Real Fines and Settlements Relative to Real Overcharges

Type of Sanction	Known	Estimated	Total
	Percent of 2005 U.S. dollars [a]		
Government fines:			
United States	5.0	0	5.0
Canada	6.0	0	6.0
European Union	3.3	0	3.3
Rest of the world	0.1	0	0.1
Subtotal fines	2.9	0	2.9
Direct buyers:			
United States	2.9	16-23	22.9

Canada	9.3 [b]	0	9.3
European Union	0	0	0
Rest of the world	0.3	0	0.3
Subtotal direct purchasers	1.2	4.8-6.9	7.0
Indirect buyers:			
United States	2.2	0.4-0.5	2.6
Canada	2.2	0	2.2
Rest of the world	0 [b]	0	0
Subtotal indirect purchases	0.7	0.1-0.2	0.8
Subtotal United States	10.1	16.8-24.0	30.4
Subtotal Canada	17.3	0	17.5
Subtotal European Union	3.3	0	3.3
Subtotal Rest of the world	0.7	0	0.7
Total all jurisdictions	4.7	4.9-7.1	10.7

Sources: Table 18A and Appendix Table 1B. Includes a few sanctions not found in Table 11.
a) Fines and settlements outside the United States are translated into U.S. dollars on the date of announcement. Includes legal fees where known. Some ratios use mid points of ranges.
b) About 18% of the Canadian settlement was distributed to non-profit organizations to benefit indirect commercial buyers and consumers.

INDUSTRY RESTRUCTURING

Industries become restructured from time to time. That is, significant changes in industry capacity or ownership patterns occur in the long run, and such restructuring may spur or obstruct collusive market conduct. In the vitamins industries, restructuring preceded, accompanied, and followed the global cartels of the 1990s.

In the decades of the 1960s and 1970s, Hoffmann-La Roche's hegemony mostly eroded as many new European and Japanese firms built new manufacturing facilities. Doubtless some cartels were formed in a few markets during these decades, but where there were actual net increases in the number of sellers or the potential for significant entry, explicit collusion was unlikely. In the 1980s a few smaller existing producers expanded, but there are relatively few examples of large-scale entry into most vitamins industries (Appendix Tables 6 and 6A). On the other hand, industry consolidation was facilitated by a number of industrial exits. Indeed, Roche engineered significant restructuring by acquiring the Danish vitamin maker Grinsted, which had important shares in the vitamin C, B1, B2, and B6 industries.

During the cartels of the 1990s, the major example of restructuring was the impressive growth of Chinese manufacturing. High prices after 1990 caused large investments in production capacity in the vitamins C, E, B1, B3, B5, B6, B9, and B12 industries—in some cases where there was no previous Chinese production. When prices collapsed after 1989

Chinese sales contracted but remained substantial. Similar but weaker production responses took place in Eastern Europe in vitamins AC, B5,and B12.

In the years immediately following the end of the vitamins cartels, several changes in ownership occurred as a result of altered business strategies.[242] Hoffmann-La Roche, for 70 years the proud global leader in the vitamins industry, decided to withdraw from vitamins manufacturing altogether. Four years of legal battles with angry customers, stubborn regulators, and mounting financial costs seem to have sapped the company's commitment. In 2003, Roche decided to sell its entire Vitamins and Fine Chemicals Division to a mid-sized Dutch chemicals maker, DSM NV. At the time Roche had set aside $3.7 billion to pay for antitrust-related costs (WSJ 2/11/03). Even though Roche agreed to absorb all liabilities for still-lingering vitamins antitrust suits, DSM got the division in 2004 for a song (only $2.1 billion). In 2002, after vitamin prices had come down to earth, the Division had 7,500 employees generating annual sales of $2.3 billion, of which $1.6 billion was vitamins.

In late 2001 Aventis announced the sale of its Rhone-Poulenc animal nutrition division to CVC Capital Partners, a UK venture-capital firm. Besides its considerable assets in vitamins, the division included the amino acid methionine and feed enzymes. CVC's payment was a mere $267 million. In June 2002 CVC sold these assets to Drakkar Holdings, a Belgian holding company, which renamed its vitamins business Adisseo; that same month the EC imposed fines on the methionine cartel, including Aventis. Adisseo achieved 2004 sales of about $600 million from plants in France, Spain, and the United States. Whether it was profitable is doubtful because Adisseo was sold yet again in 2005 to Blue Star Group, a unit of China National Chemical Corp. ("ChemChina"), one of the largest companies in the Chinese chemicals industries.

In late 2000 Takeda Chemical Industries, the largest Japanese defendant, also withdrew from the vitamins industry. Takeda's substantial physical and technological non-Japanese assets in this market were sold for less than $225 million to the world's number two producer, BASF.[243] Takeda's Japanese vitamins assets were transferred to a joint venture two-thirds owned by BASF. In a detailed analysis of the acquisition, the UK Competition Commission related BASF's stated motives for the purchase (UKCC 2001:7). BASF said that it wanted to gain technological expertise and substantial market shares in vitamins B1, B2, B6, C, and folic acid. Takeda was the second ranking manufacturer in the world with global shares of 20 to 25% in each of these products, except vitamin B2 where it was third. Moreover, because BASF had historically concentrated its vitamins portfolio on feed-grade vitamins, the Takeda deal would give BASF added strength in the food and pharmaceutical marketing channels. For example, in 2000 BASF had no human-grade vitamin C production capacity, whereas Takeda's global share of this market was 38%; similarly, Takeda's share of human-grade B2 (21%) was seven times its share of animal-grade B2 (ibid.: Table 2.1). Together with plant expansions, the Takeda acquisition gave BASF a 30% global market share in vitamins in 2001. Finally, said BASF, broadening its product line would permit it to capture significant economies of scope in distributing bulk vitamins and in the downstream premix market.[244] In other words, BASF wanted to imitate Roche's formula for success.

[242] Besides the examples mentioned in the text that follows, Reilly Industries decided to sell its choline chloride plant in Belgium.

[243] In January 2006, following up on the 2001 agreement, Takeda sold its remaining interest in the vitamins join venture to BASF.

[244] While the products involved on this acquisition did not involve horizontal consolidation, BASF had been number two in the premix business for decades. If Takeda had any potential for expansion into premixes, allowing the acquisition was of doubtful wisdom.

THE *EMPAGRAN* CASE

Of all the hundreds of suits filed in U.S. courts response to international price fixing, there is one that had the potential for profoundly changing the landscape of antitrust law. In early 2004, the U.S. Supreme Court agreed to hear arguments in a case named *Empagram et al. v. F. Hoffmann LaRoche et al.* (Henning 2004). The respondents (plaintiffs) in this case are a group of foreign feed manufacturers and wholesalers that bought bulk vitamins in the 1990s Empagran is an Ecuadorian company, and its purchases occurred wholly outside the United States in a country that has no laws that permit private antitrust suits to recover damages from price-fixing conduct.[245] The respondents (defendants) were the companies convicted of international price fixing of bulk vitamins in several jurisdictions. Prior to a decision the defendants had agreed to pay record amounts of compensation to thousands of U.S. buyers of vitamins stemming from private treble-damage actions under the 1890 Sherman Act. Empagram wanted to have the same right to sue as U.S. buyers, even though its purchases are "wholly foreign".

On January 17, 2003 by a 2-1 vote a panel of the U.S. Court of Appeals for the District of the District of Columbia found for the plaintiffs; this decision "…in effect opened the doors of the courthouse to the world" (Henning 2003:1). On September 11, 2003 the full Court of Appeals voted 4-3 to sustain the panel's January decision:

> "The same conduct injures both foreign plaintiffs and domestic plaintiffs, and is clearly the conduct that Congress aims to reach with our antitrust laws" (*ibid.*).

The Appeals Court was referring to a feature of the Sherman Act called extraterritoriality. This feature arises from the language of the Sherman Act, which declares illegal all explicitly collusive pricing conduct that "affects trade and commerce of the United States." That is, price-fixing agreements that are carried out inside or outside United States' territory are illegal because they affect sales in the United States. Without such a provision U.S. price fixers could escape prosecution simply by chartering a boat and meeting 20 miles offshore. Moreover, legal cartels such as U.S. Webb-Pomerene export associations might be tempted to control domestic prices through their export activities. Similarly, collusion on exports to the United States would go unpunished were it not for the extraterritorial reach of the Sherman Act. However, until this suit was initiated, it was generally assumed that transactions wholly outside the U.S. market would not qualify for treble damages in private suits. Thus, this principle of "partial" extraterritoriality is widely accepted as an essential feature for the effectiveness of U.S. (and other nations') antitrust laws, but how extensive this feature should be is the nub of the issue.

As a legal matter there are two separable issues to be considered, one of subject-matter jurisdiction and one of standing in private antitrust suits (Hausfeld *et al.* 2004, Shapiro *et al.* 2004). The subject-matter issue in *Empagram* is whether a 1982 amendment to the Sherman Act called the Foreign Trade Improvements Act (FTAIA) applies to "wholly foreign" direct purchases from a global cartel. This amendment was intended to clarify what type of commerce is actionable under the antitrust laws. The FTAIA authorizes the application of Section 1 of the Sherman Act when the defendant's conduct affects both domestic (U.S.) and foreign commerce *if* such conduct has "…a direct, substantial, and reasonably foreseeable effect…" on U.S.

[245] Proctor & Gamble Co. and six of its foreign affiliates were originally among the plaintiffs, but their claims are being held in abeyance (Hausfeld, *Appellants' Response to the Appellees' Petition for Rehearing and Petition for Rehearing en Banc, Empagran S.A .et al., Appellants, v. F Hoffmann-LaRoche, Ltd. et al., Appellees* (March 24, 2003), 2. There is also an Australian respondent; Australia does permit single-damages private suits.

consumers, producers, or exporters (Davis 2003: 31) [246] The plaintiffs believe that the FTAIA does not apply to international cartels, only to export sales (Hausfeld 2004: 3-4). Even if the law applies to the plaintiffs' purchases, the effects on U.S. commerce were direct, substantial and foreseeable.

The second issue in *Empagran* is whether the FTAIA extends the protection of U.S. courts to antitrust violations when the "foreign effect" is a cartelized price paid by a defendant on a transaction outside the United States. Mehra (2004) distinguishes two views on standing and extraterritoriality: the "narrow view" that requires U.S. marketplace participation and the "broad view." This latter situation might be called "full extraterritoriality." The plaintiffs argue that full extraterritoriality will serve the purposes of the Sherman Act because they are direct buyers clearly injured by the cartel's illegal conduct, their claims will deter conduct that adversely affects U.S. commerce, and their claims can be easily managed simultaneously with those of domestic direct buyers (*ibid.* 4). Mehra (2004) argues that full extraterritoriality serves to enhance the DOJ's amnesty program, encourages more settlements of civil suits, and promotes cartel deterrence.

In early 2004, the Supreme Court agreed to hear this case because decisions in two other Circuits are split on the issue. In the 2001 *Kruman* decision in the 2nd Circuit in New York permitted wholly foreign buyers to share in the roughly $500 million in damages paid by Sotheby's and Christie's after the two auction houses were convicted of price fixing (Id.). However, in *Den Norske Stats Oljeselkap* the same year by the 5th Circuit in New Orleans concerning a global conspiracy in the market for heavy lift marine barges turned down a similar suit by a Norwegian oil company on the grounds that it did not have jurisdiction.

The Supreme Court received 19 *amicus* briefs in the *Empagran* appeal. Four of these briefs, from seven foreign nations, made the case that extending standing to foreign purchases would encourage forum shopping, undermine these countries' leniency programs, and be adverse to international comity. Davis (2004) interpreted these briefs as supporting greater international cartel activity p. 60). The United States Government also argued that its highly successful corporate leniency program would be imperiled by the increased private antitrust liability that would be faced by leniency applicants should the plaintiffs prevail (Taft and Graubert 2004). It also "stretched to find international conflicts" that were irrelevant to the vitamins case (*ibid*.). However, each of these governments' positions was opposed by three *amicus* briefs submitted by academic legal scholars.[247] Three briefs in support of the defendants were sponsored by business organizations, which argued that a decision in favor of the plaintiffs would unnecessarily intrude into the free functioning of markets and would make life difficult for multinational corporations.

The Supreme Court's unanimous decision of June 2005 contained long sections on the importance of retaining comity, but failed to rule on the most interesting issue. Rather, it

[246] Davis, U.S. Antitrust Treatment of International Cartels, 17 *Antitrust*, 31-35 (2003) (surveys six appellate decisions in 2002-2003 in which the courts have attempted to clarify the FTAIA.)

[247] It is notable that all five of the briefs submitted by academic amici were in support of the plaintiffs. See Bernheim, *Brief of Certain Professors of Economics as Amici Curiae in Support of Respondents, F. Hoffmann-LaRoche, et al., Petitioners v. Empagran et al., Respondents, et al.*, 2003 U.S. Briefs 724. (March 15, 2004), Bush Brief Amicus Curiae in Support of Respondents, No. 03-742, F. Hoffmann LaRoche, Ltd. et al., Petitioners, v. Empagran S.A., et al., Respondents, 2003 U.S. Briefs 724. (March 15, 2004), Michaels, Buxbaum, and Watt. *Brief of Amici Curiae Law Professors in Support of Respondents , F. Hoffmann-LaRoche, et al., Petitioners v. Empagran et al., Respondents, et al.,* 2003 U.S. Briefs 724, (March 15, 2004), First and Fox . *Brief of Amici Curiae Legal Scholars in Support of Respondents, F. Hoffmann-LaRoche, et al., Petitioners v. Empagran et al., Respondents, et al.,* 2003 U.S. Briefs 724. (March 15, 2004), Stiglitz and Orszag, *Brief of Amici Curiae Economists in Support of Respondents, F. Hoffmann-LaRoche, et al., Petitioners v. Empagran et al., Respondents, et al.*, 2003 U.S. Briefs 724 (March 15, 2004).

remanded the case back to the DC Court of Appeals to consider whether the foreign and domestic injuries caused by the vitamins cartels were interdependent. This was odd because appeals are to be decided the assumption that the plaintiffs' allegations are true, and Empagran *et al.* strongly asserted interdependence (Sprigman 2006). On June 28, 2005 the Appeals Court decided that U.S. courts have no subject-matter jurisdiction (i.e., Empagran et al. had no case) by applying a "narrow proximate cause test" (Joshua 2005). That is, the Appeals Court deemed as "plausible" the plaintiffs' theory that prevention of international geographic arbitrage was a necessary feature of the vitamins cartels, but decided that such arbitrage did not "give rise to" a direct causal relationship between fixing prices in the United States and the injury to buyers located abroad.[248] If buyers are to sue for wholly foreign cartel damages in the future, some sort of direct connection will have to be documented between them and the U.S. price-fixing conduct, such as ownership if industry assets in both jurisdictions.

OVERVIEW AND CONCLUSIONS

This paper is a comprehensive examination of the global bulk vitamins cartels of the 1980s and 1990s. In terms of its precision and breadth of coverage, the quantitative information now available on vitamins surpasses that of almost any other modern cartel. For example, the internal records of the major defendants have made available summaries of monthly transaction prices for 53 bulk vitamin products[249] over periods of up to 22 years.

The size of these cartels is extraordinary. Evidence is presented that these 16 interrelated cartels were collectively the largest discovered international price-fixing schemes of the late 20th century. Affected real commerce in the 1990s totaled 30.6 billion 2005 U.S. dollars, and direct overcharges mounted to 11.5 billion.[250] The formation of the cartels by and large occurred in markets that were in terms of their structures and historical modes of behavior ideally suited for overt collusion. Although organizationally similar in many respects, the cartels also displayed a wondrous variety of collusive conducts. The vitamins cartels endured twice as long as the average international cartel. Only four of the cartels died natural deaths. Had it not been for public and private investigations in the United States two-thirds of them might be operating clandestinely today.

On the other hand, vitamins cartels were typical of modern international cartels in several ways. The percentage increases in bulk vitamin prices wrought by the cartels averaged about 38%, which is about average for discovered international cartels since 1990. Also, the vitamins cartels were typical in their geographic spread: affected sales and overcharges were

[248] The connection created between the domestic effect (raising prices in the United States) and the foreign conduct (raising keeping prices abroad within a narrow band above of below the U.S. price so as to prevent arbitrage) the Court termed "but-for causation," which is by implication indirect or non-proximate causation. Distinguishing between these two types of causality is uncommon in the social sciences.

[249] These products are grouped into 16 vitamin "families". The products vary according to grade and form.

[250] Adding the alleged collusion in the late 1980s would raise real (2005) sales and overcharges to $39 and $15 billion, respectively.

distributed roughly equally in three regions, North America, Western Europe, and the rest of the world.

Antitrust scholars and enforcement officials frequently cite the vitamins cartels as the most effectively punished international price-fixing conspiracies in history. There is little question that the convicted members of the vitamins cartels were, in absolute monetary terms, the most heavily sanctioned defendants in the history of antitrust law. From 1999 to 2005, the defendants paid an estimated $6.2 to $7.6 billion in fines and settlement payouts world-wide, of which more than 80% resulted from U.S. government and private legal actions. Moreover, 20 heavy individual criminal sentences were imposed on the managers of the cartels.[251] *However, when converted to 2005 dollars, the total monetary penalties shrank to $3.3 billion, a mere 11% of real affected sales. Therefore, it is non-controvertible that the impressive corporate monetary sanctions imposed worldwide were inadequate to deter recidivism.*[252]

Some legal writers are of the opinion that the vitamins sanctions are egregiously supra-deterrent (Waller 2003: 221-225).[253] Others, even those critical of the high settlements in U.S. private litigation, believe the sanctions in the vitamins cases were justified by the deterrence aim of antitrust (Baker 2004). In nominal monetary terms this study finds that global public and private penalties amounted to 26% of the cartels' affected commerce and 91% of their world-wide damages. U.S. monetary penalties for corporations were the world's highest, approaching but well below treble damages. Combining both public and private sanctions into the numerator, it is apparent that with a 240% ratio the U.S. legal system had the greatest potential for deterring cartel formation. No other jurisdiction came close to having punitive elements in its public-private system of anticartel penalties. The European Union lags far behind North America in its potential for cartel deterrence. Even from an (incorrect) *ex post* point of view, if its vitamins fines are the best that the EU can muster, private cartel formation ought to flourish in Western Europe. And they do (Connor and Helmers 2006).

However, the potential deterability of U.S. price-fixing penalties is a monetary illusion. Like most international cartels, the vitamins conspiracies lasted about seven years on average. Government fines were imposed from one to eight years after collusion ceased. Moreover, most private plaintiffs in the United States and Canada did not receive their settlement checks until 2003 to 2005 – five to 11 years after formal collusion terminated.[254] That is, the guilty firms *held on to their monopoly profits for as long as 17 years*[255], invested them[256], and could have earned additional profits on those profits. Delays in administering judicial remedies resulted in (1) a rising value of cartel overcharges because of the passage of time and (2) both taxpayers and buyers' compensation being paid in time-diminished currency. *Measured in real 2005 dollars, global vitamins sanctions represent merely 11% of worldwide damages, and no jurisdiction*

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[251] There were 17 men sentenced, 16 in the United States, four in Canada, and three in both countries. The United States imposed average fines of $110,000 and prison sentences of 8 months.

[252] Investigative reporter Jock Ferguson (2002) reports several accusations of independent U.S. vitamin premix makers that Roche and BASF were attempting to reassert their market dominance through loyalty rebates, full-line forcing, price discrimination, and other possibly predatory tactics. Bernheim (2002a) cites depositions from some vitamins defendants indicating that there were attempts to re-establish some cartels soon after they were exposed by the DOJ. See the Epilog below.

[253] "Based solely on harm to the US market Hoffmann [-La Roche] will have paid in excess of six times the harm it caused…" (Waller 2003:234). Waller provides no details on his sources of information.

[254] The price effects of collusion for some of the cartels extended 12 to 24 months beyond that.

[255] The first vitamins cartels were launched in late 1989, and the last antitrust penalty was paid to Australian direct purchasers in mid 2006.

[256] Even if the firms did not invest the additional profits, a safe return on investment is the opportunity cost of the overcharges.

came close to achieving punitive damages. With sanctions well below 100% of profits, no matter the probability of being caught, it is simply rational for international cartels to be formed.

Adjusting for the time value of money, U.S. penalties were below single damages.[257] Even if company penalties in the rest of the world were to be raised to levels found in the United States, cartel recidivism is still inevitable because cartelization is a crime that pays.[258]

EPILOGUE

One of the more sanguine observations of this study was the role played by Chinese vitamins manufacturers in destroying global price fixing in a few markets. Now, like a horror story in which a monster believed dead springs to life to wreck havoc one last time, the former spoilers in the world markets for vitamins have transmogrified from friends of consumers to fiends. With the assistance of a parastatal industry association, Chinese makers of vitamin C have been alleged to have fixed the price of exports to the U.S. market, where by 2005 they controlled 85% of imports (Wilke and Chen 2006, Isaacson *et al.* 2006). After a meeting in November 2001 of the newly formed Vitamin C Chapter of the China Chamber of Commerce of Medicines[259], Chinese spot export prices rose by 200% within a month. U.S. import prices doubled by mid 2003. Minutes of the meeting (posted on a public web site) clearly show the Chapter's intention to raise prices. A civil damages suit has been launched in the United States.

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[257] See Table 22A wherein the real U.S. penalties/damages ratio is shown to be 30.5%. The same ratios were 22% for Canadians and 4% for residents of the EU.
[258] When evaluating the force of expected sanctions on cartel deterrence, it is difficult to know how to weight the impact of expected individual prison sentences as compared to corporate penalties.
[259] Similar chapters have been formed for 12 other commodities.
[260] To save space, some citations can be found in Connor (2001).

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APPENDIX TABLES

Appendix Table 1. Affected Sales of the Vitamins Cartels of the 1990s

Product Market	United States [a]	Canada [b]	W. Europe [c]	Rest of World [d]	Global [f]
			Nominal U.S. dollars (millions)		
Beta carotene	392	24	571	201	1188
Canthaxanthin	116	1	490	1050	1657
Biotin (vitamin H)	144	2	128	206	480
Choline chloride (B4)	529	43.9	343.4	550	1466.3
Folic Acid (B9)	11.5	2	19.5 [e]	5 [e]	38
Vitamin A	824	58	1519	651	3052
Vitamin B1	50	7	102	79	238
Vitamin B2	138	11	234	93	476
Vitamin B3	267	8	250 [e]	260 [e]	785
Vitamin B5	184	11	308	72	575
Vitamin B6	54	15	73	103	245
Vitamin B12	112	2	150 [e]	203 [e]	467
Vitamin C	1027	72	1155	1414	3668
Vitamin D3	72	5 [e]	98	65	240
Vitamin E	1658	111	2177	791	4737
Vitamin premixes	2040	174	2625	2449	7288 [e]

Total 16 products	7619	547	10243	8192	26601

a) From Bernheim (2002a)

b) Currency rate is C$1 = US$0.67. Sales derived from government statements of fact that contain defendants' affected sales and a cartel's affected sales.
c) Extracted from the European Commission Decision of 21 November 2001 (Case COMP/E-1/37. 512 - Vitamins) printed in the *Official Journal* on 10 January 2003. Recitation 18 contains 1994-1999 sales in euros. Years 1990-1993 are estimated by backward projections. Converted into U.S. dollars using the average daily interbank rate for the affected period (€1 ranged from 1.19 to 1.23 dollars).

d) A residual amount.
e) Estimated by the author from information in Connor (2001) and other sources cited therein.

f) From Bernheim (2002a:33), who summarizes the Roche Data Books.

Appendix Table 1A. Affected Sales of the Vitamins Cartels of the late 1980s

Product Market	United States [a]	Canada [b]	W. Europe [b]	Rest of World [b]	Global [b]
			Nominal U.S. dollars (millions)		
Beta carotene	46.7	2.9	67.9	23.9	141.4
Canthaxanthin	52.2	0.5	220.5	272.5	745.7
Biotin (vitamin H)	96.4	1.4	85.6	137.8	321.1
Choline chloride (B4)	0	0	0	0	0
Folic Acid (B9)	0	0	0	0	0
Vitamin A	247.9	17.4	456.9	195.8	918.0
Vitamin B1	90.7	8.3	120.8	93.5	281.8
Vitamin B2	140.1	11.2	237.5	94.4	483.1
Vitamin B3	0	0	0	0	0
Vitamin B5	71.6	4.3	119.8	28.0	223.7
Vitamin B6	88.9	24.7	120.2	169.5	403.3
Vitamin B12	0	0	0	0	0
Vitamin C	834.0	58.5	937.9	148.2	2978.4
Vitamin D3	8.5	0.6	11.6	7.7	28.3
Vitamin E	336.6	22.5	441.9	160.6	961.6
Vitamin premixes	526.1	44.9	677.3	631.3	1879.9
Total 16 products	1974	142.7	2693.5	2140	6950.6

a) From Bernheim (2002a: iii-9)

b) Extrapolated from the region's sales in the 1990s in Appendix Table 1 times the ratio of US affected sales in the late 1980s to the affected sales in the 1990s.

Appendix Table 1B. Real Affected Sales of the Vitamins Cartels of the 1990s

Product Market	United States [a]	Canada [b]	W. Europe [c]	Rest of World [d]	Global [f]
			2005 U.S. dollars (millions) [g]		
Beta carotene	452.1338	32.29527	627.4725	221.722	1333.624
Canthaxanthin	133.7947	9.342561	538.4615	1173.889	1855.487
Biotin (vitamin H)	174.9696	12.27217	147.806	234.4583	569.5061
Choline chloride (B4)	568.6513	49.81774	471.1316	651.2729	1740.874
Folic Acid (B9)	13.97327	1.944107	23.09469	5.920663	44.93273
Vitamin A	976.3033	74.64455	1680.31	739.1304	3470.388
Vitamin B1	60.75334	8.262454	117.7829	93.54648	280.3452
Vitamin B2	166.4656	13.87214	266.2116	108.8993	555.4487
Vitamin B3	316.3507	17.65403	276.5487	289.4737	900.0271
Vitamin B5	218.0095	16.82464	340.708	78.94737	654.4895
Vitamin B6	65.61361	18.1045	84.29561	121.9657	289.9794
Vitamin B12	136.0875	3.28068	173.2102	239.1948	551.7731
Vitamin C	1247.874	87.48481	1333.718	1674.364	4343.44
Vitamin D3	83.04498	5.767013	107.6923	73.15701	269.6613
Vitamin E	1964.455	140.9953	2408.186	895.881	5409.517
Vitamin premixes	2417.062	174.1706	2903.761	2830.664	8325.657
Total 16 products	8995.541	666.7325	11500.39	9432.485	30595.15

a) From Bernheim (2002a)
b) Currency rate is C$1 = US$0.67. Sales derived from government statements of fact that contain defendants' affected sales and a cartel's affected sales.
c) Extracted from the European Commission Decision of 21 November 2001 (Case COMP/E-1/37. 512 - Vitamins) printed in the *Official Journal* on 10 January 2003. Recitation 18 contains 1994-1999 sales in euros. Years 1990-1993 are estimated by backward projections. Converted into U.S. dollars using the average daily interbank rate for the affected period (€1 ranged from 1.19 to 1.23 dollars).
d) A residual amount.
e) Estimated by the author from information in Connor (2001) and other sources cited therein.
f) From Bernheim (2002a:33), who summarizes the Roche Data Books.
g) Mean of U.S. and EU producer price indexes.

Appendix Table 2. Monetary Antitrust Sanctions, Vitamins Cartels, by Product, 1999-2006

PRODUCT: Company	Fines				Private Suits U.S. (Can.) [a]	Total
	U.S.	Can.	EU	Other Govt.		
	Million current U.S. dollars					
VITAMIN A:						
Roche	74.5[e]	3.6 [e]	75.9	3.1[e]	320-458 (4.9)	484-524
BASF	22.4[e]	1.1 [e]	41.0	1.5[e]	74-105 (1.4)	142-151
Rhone-Poulenc	0[b]	3.6 [e]	0	1.0[e]	170-244 (4.9)	180-201
Cartel	96.9	8.6	116.9	5.6	563-806 (11.2)	792-891
VITAMIN B1:						
Roche	0[?]	0[?]	0[c]	0[?]	19.5-28	19.5-22.8
BASF	0[?]	0	0[c]	0[?]	0	0
Takeda	0[?]	0[?]	0[c]	0[?]	23.1-33	23-33
Cartel	0[?]	0[?]	0[c]	0[?]	42.6-61 (0)	43-61
VITAMIN B2:						
Roche	11.8[e]	1.1 [e]	37.3	0[?]	50.7-73 (1.2)	102-124
BASF	8.1[e]	0.4 [e]	16.8	0[?]	26.9-38 (0.2)	52-63
Takeda	9.1[e]	0	7.8	0[?]	24.0-34 (0.5)	41-51
Rhone-Poulenc	0[b]	0	0.0	0[?]	0 (0)	0
Cartel	28.0	1.5	61.8	0[?]	101.5-145 (2.1)	196-238

VITAMIN B3:						
Lonza	10.5	0.61	Pend	0[?]	55 (1.3)	61-72
Degussa	13.0	1.37	Pend	0[?]	17 (0.1)	31
Reilly	2.0	0.02	Pend	0[?]	10 (0.03)	10-14
Nepera	4.0	0.12	Pend	0[?]	8 (0.1)	11-13
Cartel	29.5	2.13	Pend	0[?]	90 (1.53)	123-130
VITAMIN B4:						
Chinook	5.0	1.2	0[c]	0[?]	0 (6.9)	13-16
Mitsui	0 [b]	0.4	0[c]	0[?]	100-120 (0.4)	101-121
DuCoa	0.5	0	0[c]	0[?]	0 (0.4)	0
BASF	0[?]	0	46.6	0[?]	10-12 (0)	57-59
Akzo Nobel	0[?]	0	28.0	0[?]	14-16 (0)	42-44
UCB	0[?]	0	13.8	0[?]	17-19 (0)	31-33
Cartel	5.5	1.6	88.4	0[?]	141-167 (7.7)	236-262 [d]
VITAMIN B5:						
Roche	9.7[e]	0.7 [e]	47.9	0[?]	41.8-60 (0.7)	100-118
BASF	4.7[e]	0.4 [e]	31.2	0[?]	15.6-22 (0.7)	52-58
Daiichi	25.0	2.0	20.8	0.1	65.6-94 (0.7)	115-143
Cartel	39.4	3.1	98.9	0.1	123.0-177 (2.1)	266-320
VITAMIN B6:						
Roche	0?	- -	0[c]	0[?]	17.8-26	18-26
Daiichi	0[?]	0[?]	0[c]	0[?]	12.7-18	13-18
Takeda	0[?]	0[?]	0[c]	0[?]	9.1-13	9-13
Cartel	0[?]	0[?]	0[c]	0[?]	39.6-57 (0)	40-57
VITAMIN B12:						
Rhone-Poulenc	0[b]	1.8	0	0[?]	6.8-10 (0.4)	7.8-11
Hoechst	0[?]	2.0	0	0[?]	2.2-3.0 (0.03)	4.2-5.0
Cartel	0[?]	3.8	0	0[?]	9.1-13 (0.4)	12.0-16.0
VITAMIN C:						
Roche	86.0[e]	7.5 [e]	57.9	3.1[e]	386.0-529 (8.8)	541-684
BASF	5.9[e]	1.0 [e]	13.0	1.4[e]	19.5-22.8 (1.1)	42-50
Takeda	69.2[e]	2.8	25.1	0.9[e]	164.9-236 (3.4)	275-346
E. Merck	14.0	0.6	8.2	0?	91.9 (0.6)	90-120
Cartel	175.1	11.9	104.2	5.4	645.4-90.5 (13.8)	948-1164
VITAMIN D3:						
Roche	0[?]	0	18.6	0[?]	0	18.6
BASF	0[?]	0	6.7	0[?]	0	6.7
Rhone-Poulenc	0[?]	0	4.5	0[?]	0	4.5
Solvay	0[?]	0	8.1	0[?]	0	8.1
Cartel	0[?]	0	37.9	0[?]	0 (0)	37.9

VITAMIN E:						
Roche	137.2[e]	7.0 [e]	88.5	3.1[e]	590-845 (8.0)	833-1088
BASF	84.7[e]	1.9 [e]	79.7	1.5[e]	280-401 (2.4)	449-570
Rhone-Poulenc	0[b]	6.4 [e]	0.0	1.0[e]	213-306 (9.6)	229-322
Eisai	40.0	1.6	11.7	0.2	149-212 (1.3)	204-267
Cartel	261.9	16.9	179.9	5.8	1231-1764 (21.3)	1715-2247
FOLIC ACID (B9):						
Roche	0[?]	0[?]	0[c]	0[?]	5.8-8.5	6-9
Takeda	0[?]	0[?]	0[c]	0[?]	5.2-7.0	5-7
Kongo	0[?]	0[c]	0[c]	0[?]	3.6-5.0	4-5
Sumika/Sumitomo	0[?]	0[c]	0[c]	0[?]	4.5-6.0	5-6
Cartel	0[?]	0[?]	0[c]	0[?]	19.0-28	19-28
BIOTIN (H):						
Roche	0[?]	0.2 [e]	0[c]	0[?]	9.2-16 (0.16)	9.5-16
BASF	- -	- -	0[c]	0[?]	0 (0)	0
Lonza	0[?]	0[?]	0[c]	0[?]	5.6-9.0 (0.01)	6-9
E. Merck	0[?]	0[?]	0[c]	0[?]	1.8 (0.0)	1.8
Sumitomo	0[?]	0[c]	0[c]	0[?]	30.2-40 (0.01)	30-40
Tanabe	0[?]	0[c]	0[c]	0[?]	60-80 [f] (0.01)	60-80 [f]
Cartel	0[?]	0.2	0[c]	0[?]	109-147 (0.4)	109-147
BETA CAROTENE:						
Roche	59.1[e]	3.8	42.6	0[?]	253-363 (3.2)	362-462
BASF	2.5[e]	0.3	38.3	0[?]	7.4-11 (1.4)	50-54
Cartel	61.6	4.1	80.9	0[?]	260-374 (4.6)	412-516
CANTHAXANTHIN:						
Roche	0[?]	0[?]	41.3	0[?]	7.4-11 (0.2)	48-52
BASF	0[?]	0[?]	37.1	0[?]	0 (0.0)	37
Cartel	0[?]	0	78.4	0[?]	7.4-11 (0.2)	85-89
VITAMIN PREMIXES:						
Roche	121.6[e]	17.5[e]	0[?]	0[?]	522-748 (21.8)	684-910
BASF	96.7[e]	10.9[e]	0[?]	0[?]	320-457 (11.7)	440-577
Cartel	218.3	28.3	0[?]	0[?]	843-1205 (33.5)	1124-1387
TOTAL OF 16	915.2	82.3	847.3	16.9	4000-5700 (105)	6200-7600

Sources: Appendix Table 10, Government decisions, plea agreements, and press releases; Boies (2004), Denger (2005), and other settlement announcements. Market shares from Appendix Table 5.
- - Not applicable (no known sales).
? = Sales but no known fines; in some cases ability to pay may explain low sanctions.
e = Estimated from share of cartel's affected sales in the jurisdiction and company's share of market.
a) Except for vitamins B3 and B4, payouts are estimated to be proportional to a company's affected sales in each

product line; total U.S. payouts are between $2860 and $3,360 million; Canadian and legal fees of $US 105 million (19.2% of affected sales).
b) Amnesty or large leniency discount
c) Statute of limitations explains low or zero fines
d) Boies (2004) claims that damages were $45 million in this market, implying a 378% payout of damages.
f) Boies (2004) states that because Tanabe was the last to settle, it paid more than 40 times the company's damages.
g) Used an exchange rate of C$1 = US$ 0.8177.

Appendix Table 2A. Monetary Antitrust Sanctions, Relative to Affected Sales, 1999-2006

PRODUCT: Company	Fines				Private U.S.(Canada) Suits [a]	Total Cartel
	U.S.	Canada	EU	Other Govt.		
	Percent					
VITAMIN A:						
Roche	17.2	17.2	11.6	1.5	74-106 (8.5)	37-40
BASF	21.7	16.3	9.3	0.5	72-102 (20.0)	17-18
Rhone-Poulenc	0[b]	13.5	0[b]	40.0	75-107 (20.1)	30-33
Cartel	12.1	15.4	8.4	1.1	70-112 (20.1)	29-32
VITAMIN B1:						
Roche	0	0	0[c]	0	141-203	23-27
BASF	0	0	0[c]	0	0	0
Takeda	0	0	0[c]	0	142-202	36-52
Cartel	0	0	0[c]	0	142-203 (0)	26-37
VITAMIN B2:						
Roche	20.0	21.2	34.5	0	86-124 (22)	49-59
BASF	26.1	19.2	24.7	0	82-123 (12)	40-41
Takeda	37.9	0	26.0	0	100-142 (23)	51-63
Rhone-Poulenc	0	0	0	0	0	0
Cartel	24.6	16.2	30.0	0	89-127 (23)	46-56

VITAMIN B3:						
Lonza	11.5	9.6	0	0	60 (21)	13-16
Degussa	22.0	549?	0	0	29 (40)	26
Reilly	6.9	6.5	0	0	34 (12)	18-25
Nepera	5.3	49.0	- -	0	11[d] (40)	14-17
Cartel	11.6	28.0	0	0	35 (24)	17-18
VITAMIN B4:						
Chinook	2.9[d]	3.4[d]	- - [d]	0	0[d]	5-6[d]
Mitsui	0	16.3	- - [d]	0	67-81	56-68
DuCoa	0.35[d]	0[d]?	- - [d]	0	0[c]	4[d]
BASF	- -	- -	36.1	0	71-86[e]	39-40
Akzo Nobel	- -	- -	21.7	0	65-74[e]	21-22
UCB	- -	- -	13.1	0	67-75	14-15
Cartel	1.2	3.9	24.4	0	27-32	19-21
VITAMIN B5:						
Roche	16.2	18.1	35.2	0	70-100 (19)	47-55
BASF	20.4	12.4	33.9	0	68-96 (21)	45-50
Daiichi	25.8	56.7	56.2	0.3	68-97 (19)	66-83
Cartel	22.0	29.6	37.5	0.2	69-99	53-64
VITAMIN B6:						
Roche	0?	- -	0[c]	0	136-200	15-21
Daiichi	0?	0?	0[c]	0	187-265	45-62
Takeda	0?	0?	0[c]	0	94-134	36-52
Cartel	0?	0?	0[c]	0	132-190 (0)	23-32
VITAMIN B12:						
Rhone-Poulenc	0[b]	11.4	0	0	8-12 (27)	2-3
Hoechst	0?	204.0	0	0	28-38 (30)	10-12
Cartel	0?	23.5	0	0	10-14 (25)	3-4
VITAMIN C:						
Roche	17.7	19.3	9.8	1.8	80-190 (23)	42-53
BASF	22.7	19.6	10.2	5.6	75-108 (22)	23-27
Takeda	21.6	18.6	27.3	0.3	52-74 (23)	36-45
E. Merck	22.6	19.7	8.9	0?	148 (21)	35-47
Cartel	19.6	19.1	11.6	0.8	72-101 (22)	38-47
VITAMIN D3:						
Roche	0?	0?	60.0	0	0	19.0
BASF	0?	0?	33.5	0	0	13.4
Rhone-Poulenc	0?	0?	45.0	0	0	18.8

Solvay	0?	0?	21.9	0	0	11.6
Cartel	0?	0?	38.7	0	0 (0)	15.8
VITAMIN E:						
Roche	17.4	17.2	10.2	0.7	75-107 (20)	39-51
BASF	22.7	15.4	13.6	0.7	75-108 (20)	38-48
Rhone-Poulenc	0[b]	13.0	0	?	73-106 (20)	35-49
Eisai	19.3	24.4	49.0	?	72-102 (19)	39-51
Cartel	15.8	15.5	8.9	0.8	74-106 (20)	38-50
FOLIC ACID (B9):						
Roche	0?	0?	0[c]	0	414-607	49-74
Takeda	0?	0?	0[c]	0	163-219	63-88
Kongo	0?	0[d]	0[c]	- -	164-227	105-132
Sumika/Sumitomo	0?	0[d]	0[c]	- -	188-250	102-122
12.18	0?	0?	0[c]	0	207-304 (0)	66-97
BIOTIN (H):						
Roche	0?	0?	0[c]	0	16-28 (20)	5-8
BASF	- -	- -	0[c]	0	0 (0)	0
Lonza	0?	0?	0[c]	0	21-33 (0)	25-38
E. Merck	0?	0?	0[c]	0	20 (0)	5
Sumitomo	0?	0[c]	0[c]	0	100-133 (3)	33-44
Tanabe	0?	0[c]	0[c]	0	300-400 (3)	70-93
Cartel	0?	0[c]	0[c]	0	76-102 (20)	24-33
BETA CAROTENE:						
Roche	15.6	22.6	11.5	0	67-95 (19)	41-53
BASF	20.8	4.4	19.2	0	62-92 (19)	16-17
Cartel	15.7	17.0	14.2	0	66-95 (19)	35-43
CANTHAXANTHIN:						
Roche	0?	0?	11.1	0	6.4-9.5 (20)	3.8-4.1
BASF	- -	0?	31.4	0	0 (20)	9.3
Cartel	0?	0?	16.0	0	6.4-9.5 (20)	5.1-5.4
VITAMIN PREMIXES:						
Roche	19.2	32.3	0?	0	83-118 (40)	27-36
BASF	24.9	33.4	0?	0	82-118 (35)	40-53
Cartel	21.4	32.5	0?	0	83-118 (39)	31-38
TOTAL OF 16	12.1	15.0	8.2	0.2	52-74 (19.6)	23.3-28.5

Sources: Appendix Tables 2 and 12.

- - Not applicable (no known sales).
? = Sales but no known fines; in some cases ability to pay may explain low sanctions.
e = Estimated from share of cartel's affected sales in the jurisdiction and company's share of market.
a) US settlements divided by US affected sales; same for Canada.
b) Amnesty or large leniency discount
c) Statute of limitations explains low or zero fines
d) Ability to pay may explain low sanction.

Appendix Table 2B. Monetary Antitrust Sanctions, Relative to Overcharges, 1999-2006

PRODUCT: Company	Fines				Private U.S. Suits [a]	Total
	U.S.	Canada	EU	Other Govt.		
	Percent					
VITAMIN A:						
Roche	62.5[e]	45[e]	18.8		225-323 (61)	121-131
BASF	66.3[e]	48[e]	35.0		219-311 (61)	54-58
Rhone-Poulenc	0[b]	45[e]	0		229-328 (70)	102-114
Cartel	37.1	47.3	31.5	2.8	216-310 (62)	93-105
VITAMIN B1:						
Roche	0?	0?	0[c]	0	780-1120 (0)	189-221
BASF	0	0	0[c]	0	0 (0)	0
Takeda	0?	0?	0[c]	0	770-1100 (0)	299-429
Cartel	0?	0?	0[c]	0	775-1109 (0)	237-337
VITAMIN B2:						
Roche	87.4[e]	92[e]	130.9	0	376-541 (97)	187-228
BASF	114.1[e]	86[e]	93.3	0	379-535 (53)	156-189
Takeda	165.5[e]	0?	96.3	0	436-618 (98)	195-243
Rhone-Poulenc	0[b]	0?	- -	0	0 (0)	0
Cartel	107.3	70	113.2	0	389-556 (99)	176-214

VITAMIN B3:						
Lonza	73.9	61	0?	0	385 (131)	86-101
Degussa	141.3	1,717	0?	0	185 (125)	169
Reilly	43.5	55	0?	0	217 (100)	116-163
Nepera	34.2	123	0	0	68[c] (333)	100-118
Cartel	74.3	117	0?	0	121 (128)	113-119
VITAMIN B4:						
Chinook	6.9[c]	9.8[c]	0[c]	0	0[c] (58)[c]	14-17
Mitsui	0?	47	0[c]	0	205-245 (57)	167-201
DuCoa	2.1[c]	0[c]?	0[c]	0	0[e,c] (57)	1.1[c]
BASF	0	0	107.6	0	?	127-131
Akzo Nobel	0	0	64.7	0	?	71-74
UCB	0	0	36.5	0	?	47-50
Cartel	3.8	17.6	71.1	0	97-115 (55)	58-64
VITAMIN B5:						
Roche	17.0[e]	58[e]	83.2	0	226-324 (62)	121-143
BASF	66.2[e]	40[e]	79.4	0	220-310 (69)	117-130
Daiichi	83.6	181	132.5		219-314 (62)	172-214
Cartel	71.0	95	87.8	0.2	222-319 (64)	137-165
VITAMIN B6:						
Roche	0?	0	0[c]	0	539-788 (0)	41-59
Daiichi	0?	0?	0[c]	0	794-1125 (0)	123-170
Takeda	0?	0?	0[c]	0	396-565 (0)	101-146
Cartel	0?	0?	0[c]	0	550-792 (0)	63-89
VITAMIN B12:						
Rhone-Poulenc	0[b]	260[e]	0?	0	18-27 (61)	4.8-6.7
Hoechst	0?	3407	0?	0	63-86 (50)	20.6-24.5
Cartel	0?	522	0?	0	22-32 (60)	6.5-8.7
VITAMIN C:						
Roche	73.9[e]	82[e]	39.3		332-454 (96)	161-204
BASF	80.1[e]	82[e]	40.9		267-312 (92)	88-104
Takeda	90.6[e]	77	108.7		216-309 (94)	136-171
E. Merck	96.6[e]	82	35.5	0?	634 (86)	134-179
Cartel	81.6	81	48.1	2.6	301-422 (95)	145-178
VITAMIN D3:						
Roche	0?	0?	620.0	0	0	147.6
BASF	0?	0?	304.6	0	0	55.8
Rhone-Poulenc	0?	0?	409.1	0	0	194.9
Solvay	0?	0?	197.6	0	0	124.6
Cartel	0?	0?	364.4	0	0? (0)	123.1

VITAMIN E:						
Roche	45.0[e]	16.4[e]	23.2		193-277 (50)	84-110
BASF	58.8[e]	40.0[e]	29.3		194-278 (51)	82-104
Rhone-Poulenc	0[b]	33.8[e]	0		190-273 (51)	75-105
Eisai	50.0	62.9	8.6		186-265 (50)	85-111
Cartel	40.9	40.2	17.9	1.5	192-275 (51)	82-108
FOLIC ACID (B9):						
Roche	0?	0?	0[c]	0	1758-2576(0)	111-167
Takeda	0?	0?	0[c]	0	743-1000 (0)	143-200
Kongo	0?	0[c]	0[c]	0	735-1020 (0)	182-227
Sumika/Sumitomo	0?	0[c]	0[c]	0	818-1090 (0)	294-353
Cartel	0?	0?	0[c]	0	913-1346 (0)	148-219
BIOTIN (H):						
Roche	0?	117[e]	0[c]	0	91-158 (114)	24-40
BASF	0	0	0[c]	0	0	0
Lonza	0?	0?	0[c]	0	117-188 (14)	130-196
E. Merck	0?	0?	0[c]	0	120 (0)	24
Sumitomo	0?	0[c]	0[c]	0	1304-1739 (14)	171-229
Tanabe	0?	0[c]	0[c]	0	1714-2286 (20)	361-482
Cartel	0?	47	0[c]	0	433-583 (114)	127-172
BETA CAROTENE:						
Roche	503.8[e]	74	37.2	0	216-309 (63)	128-163
BASF	83.3[e]	14.3	62.2	0	247-367 (61)	53-57
Cartel	51.2	55.4	46.0	0	216-311 (62)	109-137
CANTHAXANTHIN:						
Roche	0?	0?	43.4	0	33-49 (108)	17.4-18.9
BASF	- -	0?	∞	0	0 (0)	42.5
Cartel	0?	0?	82.4	0	33-49 (108)	23.4-24.5
VITAMIN PREMIXES:						
Roche	65.2[e]	111[e]	0?	0	279-401 (130)	99-132
BASF	84.6[e]	114[e]	0?	0	280-400 (130)	96-126
Cartel	72.6	111	0?	0	280-400 (130)	98-121
TOTAL OF 16	39.7	49.6	26.8	0.6	174-248 (63)	73-90

Sources: Appendix Tables 2 and 13.

- - Not applicable (no known sales). ∞ = infinity

? = Sales but no known fines; in some cases ability to pay may explain low sanctions.

e = Estimated from share of cartel's affected sales in the jurisdiction and company's share of market.
a) A residual column. Total only approximate.
b) Amnesty or large leniency discount

c) Statute of limitations explains low or zero fines

d) Ability to pay may explain low sanction.

Appendix Table 3. Vitamin Prices, Western Europe, 1988-2003

Product: price type [a]	88	89	90	91	92	93	94	95	96	97	98	99	2000	2001	2002	2003
							euro per kilogram									
A: market	- -	39*	38.8	41	45	48	50.0	51.8	52.3	52.1	54.4	53*	37.4	35.9	38.3	40.0
E: market	- -	21*	18.6	23	27	29	28.6	30.6	30.1	30.1	31.1	26*	24.3	21.8	17.2	17.6
C: market	12[e]	11	11.5	12*	13	14	14.4	15.2*	10.1	6.9	6.9	6.9	6.8	6.0	4.1	5.8
C: minimum	- -	- -	- -	10.4	12.7	14.9	14.8	13.3	11.0	- -	- -	- -	- -	- -	- -	- -
B1: market	- -	28	27*	28	29	32	27.2*	22.7	17.3	17.7	18.7	17.9	15.5	14.9	16.0	16.8
B1: minimum	- -	- -	- -	- -	38.4	39.3	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
B2: market	- -	43	42.5*	43	50	55	57.8	60.6*	50.3	42.1	42.7	40	37.6	37.8	36.5	31.5
B2: minimum	- -	- -	- -	42.6	48.8	51.6	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
B5: market	- -	12	12*	13	15	17	18.2	18.6	18.2	18.0	19.6	19*	16.3	15.8	- -	- -
B5: minimum	- -	- -	- -	13.9	16.1	18.6	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
B9: market	- -	- -	- - *	80	- -	- -	- - *	- -	- -	47	53	51.1	51.4	45.1	- -	- -
B9: minimum	- -	- -	- -	- -	98.7	111.6	110.6	- -	- -	- -	- -	- -	- -	- -	- -	- -
D3: market	- -	- -	- -	- -	- -	- - *	35.6	41.0	40.0	37.2	43.7*	- -	38.9	34.6	--	--
H: market	- -	- -	4340	4340*	4340	4340	3,938*	3,738	2,962	2,142	1,763	1,457	- -	- -	- -	- -
Beta carotene: market	- -	- - *	- -	- -	- -	677	699	736	718	712*	730	748	- -	- -	- -	- -
Canthaxanthin: market	- -	- -	- -	- -	- -	- - *	1,244	1,289	1,286	1,253	1,233	1,250*	- -	- -	- -	- -
B6: market	- -	30*	25	30	36	46.5	32.9*	24.4	18.5	18.0	18.9	19	20.4	22.6	21.3	19.9
B6: minimum	- -	- -	24.8	42	46.2	47.8	44.8	- -	- -	- -	- -	- -	- -	- -	- -	- -

a) "Market" = EU average transaction prices 1988-1999. Data for 2000-2003 is based on U.S. import prices from major exporters translated into euros and spliced using 1997-1999 overlap years to allow for quantity differences. "Minimum" = lowest prices set by cartel.

* = cartel begins after earlier year or ends during or after later year.

Source: EC (2003: Text and Annex), STAT USA.

Appendix Table 4. Vitamin Overcharges in the EU

Product	Alternative Benchmark Prices									
	EU First Year	EU Year Before	EU Years Before	US List Before	US Contract Before	EU Year After	EU Years After	US Imports Two Years After[d]	US Imports Three Years[e]	Best Estimates[f]
	Percent									
Vitamin A	28.2	24.7	- -	65.5	82.9	- -	- -	32.7	27.8	25-28
Vitamin E [a]	23.4	52.6	43.4	69.8	92.1	- -	- -	23.2	50.5	45-55
Vitamin C	17.9	23.0	23.0	44.4	44.4	40.1	77.6	91.1	- -	20-30
Vitamin B1	5.0	7.6	5.6	0	- -	28.0	51.0	74.0	82.7	5-8
Vitamin B2	29.9	25.4	24.6	29.0	- -	5.9	28.1	37.3	51.1	25-28
Vitamin B5	38.1	45.0	45.0	40.4	- -	- -	- -	8.4	- -	40-45
Vitamin B6 [b]	45.4	13.6	- -	3.3	- -	39.7	84.6	58.5	60.3	40-45
Vitamin B9[c]	- -	- -	- -	0	- -	- -	58.5	65.8	- -	60-65
Vitamin D3	13.7	- -	- -	- -	- -	- -	- -	7.5	- -	8-14
Biotin (H)[c]	- -	0	0	- -	- -	12.5	64.8	- -	- -	15-60
Beta Carotene	- -	- -	- -	- -	- -	0	0	- -	- -	0?

- - = not available

a) Omits 1990 from cartel because one firm missing

b) Cartel ended 6/94 so only half weight for 1994 price

c) Very sparse conspiracy price data

d) Generally 1999-2000

e) Generally 2001-2003

f) The best estimate gives the greates weights to those that use the year or years before the conspiracy and the three years after the conspiracy. If the two estimates are far apart, the more conservative estimate is picked.

Source: Appendix Table 3, EC (2003), STAT USA, and *Chemical Market Reporter*

Appendix Table 5. Vitamins Market Shares, Canada, US, and Europe

Product: Company	Canada	United States	Western Europe						World				
	Years: percent												
VITAMIN A:	90-98:	90-98:	75:	88:	90-98:	98[b]:			88:	90[b]:	90-98:	98:	
Roche	42	50-55	47	46.5	43	40			46	46	40-50	45	
BASF	12	10-15	25	29.8	29	29			28	30	30-40	30	
Rhone-Poulenc	42	25-30	- -	23.7	22	22			22	20	20-30	20	
Cartel	96	95-98		100.0?	91-93	91[e]			96	96	96	96	
(Bel Vitimini, Russia)					(7-9)								
VITAMIN B1:	91-94:	91-94:	75:	90:	91:	92:	93:	91-93:	89:	91:	92:	93:	93[b]:
Roche	22	25-30	50	34	54	36	50	52	44	38	37	53	34
BASF	0[a]	0[a]	- -	18[a]	11[a]	18[a]	7[a]	16[a]	13[a]	11[a]	11[a]	11[a]	10[a]
Takeda	33	30-35	48	37	21	34	35	28	31	36	34	24	31
Cartel	55	53-57	98	88[e]	88	89[e]	91	89	88	85	82	88	75
(Chinese producers)				(12)	(12)	(11)	(9)	(11)	(9)	(15[e])	(18)	(12)	(25)
VITAMIN B2:	91-95:	91-95:	75:	91:	91-94:	94:	95:		90:	91-95:	94:	94[b]:	
Roche	49	40-45	86	48	46	44	42		55	47	43	50	
BASF	15	20-25	- -	26	29	31	27		30	29	29	30	
Takeda	20	15-20	- -	13	13	13	16		11	12	16	14	
Rhone-Poulenc	0	0	- -	0	0	0	0		0	0	0	0	
Cartel	83	80-85	- -	88[e]	88	88	85[e]		95.4	88	88	93.6	
(Coors, ADM[c])							(9)[c]			(3)	(10)[e]		
VITAMIN B3:	92-97:	92-98:	75:	92-98:					95:				
Lonza	79	34	- -	70[e]					60				
Degussa[f]	6	20-24	- -	22 [e]					18				
Reilly[f]	2	10-12	- -	8 [e]					9				
Nepera	8	28	- -	0[e]					9				
Cartel	95	92-97	- -	98[e]					96				
(Roche)			(68)[g]										
VITAMIN B4:	92-95:	92-98:		92-98:					1995:	1997			
Chinook	89	4-6		0					19	19.3			
Bioproducts/Mitsui	5	31		0					10	12.2			
DuCoa	5	15		0					18	16.3			
BASF	0	0		30-33[e]					15	9.1			
Akzo Nobel	0	0		30-33[e]					15	12.0			
UCB	0	0		25-30[e]					13	13.4			
Cartel	99	92		90-95[e]					90	82.3			
VITAMIN B5:	91-94:	91-98:	75:	91[b]:	91-98:				89:	90:	91-98:		
Roche	33	30-35	64	40-48	44 [e]				35	37	30-40		
BASF	30	10-15	- -	19-22	30 [e]				20	21	20-30		
Daiichi	33	50-55	- -	30-39	12				35	30	25-35		
Cartel	96	95-98	- -	100	86				90	90[e]	86		
(Japan, China, E. Europe)	(4)	(2-5)	- -						(10)	(10)	(14)		
VITAMIN B6:	91-94:	91-93:	75:	90:	91-93:	93:			89:	90:	91-93:	93:	
Roche	0	22-27	95	54	51	48			40	46	40	39	
Daiichi	43	10-15	- -	10	8	6			12	11	10	10	
Takeda	13	16-20	- -	12	11	10			11	13	11	11	
Cartel	56	55-60	- -	76	70	65			63	70[e]	65	60	
(BASF, "Merck", China)				(24)	(30)	(35)			(13)	(30)	(35)	(40)	
FOLIC ACID (B9):	91-93:	91-93:	75:	90[b]:	91-93:	93:			90-91:	91-93:	94:		
Roche	10-15	10-15	47[g]	43.7	35	32			42.3	59	34		
Takeda	25-30	25-30	- -	23.1	20	17			23.4	24	18		
Kongo	20 [e]	19[e]	- -	9.7	9	7			15.0	4	12		
Sumika/Sumitomo	21 [e]	21[e]	- -	23.5	20	17			19.4	3	15		
Cartel	80	80[e]	- -	100.0?	84	72			100.0?	90[e]	80[e]		
(Chinese)						(28)					(20)		
VITAMIN B12:	90-97:	91-94:	75:		91-94:					91-94:			
Rhone-Poulenc	74	70-75	- -		85[e]					80			
Hoechst	7	5-10	- -		10[e]					9			
Cartel	81	85-90	- -		95[e]					89			
(Roche)			(13)[g]										
VITAMIN C:	91-95:	91-95:	75:	91:	91-94:	94:			90:	91-94:	93:	94:	
Roche	54	45-50	68	54	51	48			47	39	40	36	
BASF	7	0-5	- -	11	11	11			7	5	6	6	
Takeda	21	30-33	16[e]	8	8	8			27	24	24	23	
E. Merck	4	4-8	- -	8	8	8			9	7	8	7	
Cartel	85	83-87	- -	82[e]	75	74			90[e]	75	79	73[e]	
(mostly Chinese)	(15)	(13-17)		(18)	(22)	(26)			(10)	(25)	(21)	(27)	
									human feed				
VITAMIN D3:	94-97:	94-97:	75:	94:	94-97:	97:			94[b]:	94[b]:	94[b]:	94-97:	97:
Roche	40	40	10[f]	29	28	27			50	38	41	40	39
BASF (1990-)	11	11	- -	22	20	18			0	21	14	15	16
Rhone-Poulenc[i]	18	18	- -	11	10	9			0	0	9[i]	9[i]	9[i]
Solvay	30	30	- -	35	38	41			50	41	33	32	31
Cartel	99	99	- -	97	96	95			100?	100?	96	96	96

VITAMIN E:	90-98:	90-98:	75:	88:	90-98:	98:			88:	90[b]:	90-98:		
Roche	37	45-50	70	42	30-40	38-40			45	43.7	35-45		
BASF	11	20-25	25[e]	29	20-30	25-29			27	27.4	20-30		
Rhone-Poulenc	44	15-20	- -	14	15-25	15-16			15	15.4	10-20		
Eisai	6	10-15	- -	7	10-20	10-12			10	9.6	5-15		
Cartel	0.98	95-100	- -	99	92	93			96	96	96		
(Chinese)				(1)		(7)							
BIOTIN (H):	91-95:	91-94:	75:	91:	91-93:	93:			90:	92[b]:	91-93:	93:	
Roche	40	40	95	37	37	37			45	44	43	43	
BASF[i]	0	0	- -	6[i]	6[i]	5.5[i]			0	0	4	4	
Lonza	19	19	- -	8	8	7.7			5	5	5	5	
E. Merck	6	6	- -	5 e	5 e	5 e			9	9	7	7	
Sumitomo	21	21	- -	12	12	12			19	17	22	22	
Tanabe	14	14	- -	26	26	26			17	20	15	15	
Cartel	100?	100?	- -	94 [e]	94 [e]	94 [e]			95	95	95	94[e]	
(IL Sung)									(5)	(5)	(5)	(6)	
BETA CAROTENE:	92-98:	93-98:			93-98:[k]			91:	93:	93-98:	2001[b]:		
Roche	69	95-100			65			79	67	66-68	70		
BASF	31	0-5			35			21	33	32-34	30		
Cartel	100	100			100			100	100	100	100		
CANTHAXANTHIN:	92-98:	94-98:			94-98:[k]				1998:		2002[b]:		
Roche	98	100			100				100		80		
BASF	2	0			0				0		20		
Cartel	100	100			100				100		100		
FEED PREMIXES:		91-97:			91-97:						91-97:		
Roche		31[e]			40 [e]						35[e]		
BASF		19[e]			20 [e]						15[e]		
Cartel		50[e]			60 [e]						50[e]		

- - = Not available

? = Seems to be total of cartel, not entire market.

a) After 1989, BASF purchased the vitamin from Roche

b) These data are planned quotas, typically allocated one year before by cartel agreements, and based on assumed volume growth

c) ADM purchased the Coors plant in 1995. In Europe ADM's share increased from 2% to 9% during 1995. The remaining fringe sales are from the GUS Group of Russia, which sold B2 mainly in Europe.

d) Maerz (1996) states that Rhone-Poulenc had a 5% world capacity share, but the company simply marketed the product made by ADM.

e) Estimated. Often the cartel's internal shares are known precisely, but the cartel total is adjusted downward to account for fringe production know from adjacent years. Other estimates use a residual regional approach based on known plant locations.

f) Degussa and Reilly owned a joint venture called Vitachem in the United States. Their respective sales in the United States are estimated from their shares of private settlements.

g) Sold by Roche in Europe but purchased under supply contracts.

h) Both manufacturers exited in 1990.

i) Supplied by Solvay but had a cartel quota in some regions.

j) Supplied by E. Merck, sold up to 88% of Merck's production.

k) In Europe, these are the shares of the combined canthaxanthin and astaxanthin markets.

Source: Connor (2001), Maerz (1996), EC Decision in *Official Journal* (21 November 2001; January 1, 2003), EC (1976), Government of Canada Statements of Facts, and press reports. The 1995 world data are generally based on global manufacturing capacities (from Maerz 1996); however, these are not shown if more reliable data are available. All other shares are based on actual or planned sales volumes. The 2000 data are from UKCC (2001: Table 2.1).

Appendix Table 6. Global Production Shares 1980-2000

VITAMIN: Companies	1980	First Episode		Second Episode			Last Available Year
		First Year	Last Year	First Year	Peak Price Year	Last Full Year	
				Percent			
VITAMIN E:		1985	1989	1990	1996	1998	1998
Roche	59	52	46	46	45	40	40
Rhone-Poulenc [b]	11	14	15	13	14	12	12
BASF	20	24	27	28	25	25	25
Eisai	8	11	15	12	11	10	10
Cartel	98	100	100	99	95	87	87
E. Merck (1991-)	0	0	0	0	1	1	1
China (1991-)	0	0	0	1	3	11	11
VITAMIN A:		1985	1989	1990	1996	1998	1998
Roche	64	53	49	48	43	43	43
BASF	26	30	29	30	28	29	29
Rhone-Poulenc	9	17	21	21	20	19	19
Cartel	99	100	99	99	91	91	91
Russia	0	0	0	0	7	8	8
China + India	1	0	1	1	2	1	1
VITAMIN C:		1985	1990	1991	1994	1995	1998
Roche	51	55	45	46	35	32	38
Takeda	18	18	26	26	21	19	17
E. Merck	13	12	9	10	7	6	7
BASF (1982-)	0	5	7	7	5	5	6
Cartel	83	90	87	89	68	62 [c]	68
China	3	4	8	8	24	34	32
India	3	2	1	1	1	1	0
E. Europe	2	3	3	2	6	3	1
Grinsted (Roche 1981)[a]	7	0	0	0	0	0	0
CHOLINE CHLORINE(B4):				1988	1995	1998	2000
Bioproducts/Mitsui	NA	NA	NA	22	32	35	52
Chinook	NA	NA	NA	30	38	39	27
DuCoa	NA	NA	NA	49	31	26	21
Cartel (U.S. Only)				100	100	100	100
						1997	
Akzo Nobel						12.0	
BASF						9.1	

UCB						13.4	
Bioproducts/Mitsui						12.2	
Chinook						19.3	
DuCoa						16.3	
Cartel (world)						82.3	
ICI						5.0	
Ertisa						1.5	
BETA CAROTENE:		1988	1990	1991	1996	1998	1998
Roche	93	87	84	82	75	74	74
BASF	5	12	16	18	25	26	26
Cartel	98	99	100	100	100	100	100
Sumitomo (exit 1989)	2	1	0	0	0	0	0
CALPAN (B5):		1985	1990	1991	1996	1998	1998
Roche	28	39	39	36	37	37	37
Daiichi	32	29	30	29	30	25	25
BASF (enter 1981)	0	17	17	21	20	21	21
Cartel	60	85	86	86	87	83	83
Alps Pharma (JP)	15	11	10	10	6	6	6
Daitaom (exit 1982)	7	0	0	0	0	0	0
Hoffman-Taff (exit 1980)	12	0	0	0	0	0	0
E. Europe (1981-)	0	6	4	4	6	8	8
China (1996-)	0	0	0	0	2	5	5
NIACIN (B3):				1991	1993	1998	1998
Lonza	68	NA	NA	58	58	57	57
Degussa	4	NA	NA	15	15	18	18
Reilly Industries	4	NA	NA	7	7	9	9
Nepera	12	NA	NA	6	9	7	7
BASF (1989 only)	0	NA	NA	0	0	0	0
Cartel	88			86	89	91	91
Japan	5	3	3	2	1	2	2
China	0	0	0	0	0	3	3
RIBOFLAVIN (B2):		1985	1990	1991	1994	1995	1998
Roche	66	71	56	54	44	42	42
BASF (1982-)	0	21	30	30	27	26	20
Takeda (1990-)	0	0	3	3	17	17	15
Rhone (1994-)	0	0	0	0	2	9	11
Cartel	66	92	89	87	90	94	87
Grinsted (Roche 1981)[a]	18	0	0	0	0	0	0
Merck (exit 1984)	8	0	0	0	0	0	0

Tanabe (exit 1992)	9	8	7	7	0	0	0
China (1984-1993)	0	1	0	0	0	0	0
Coors/ADM (1989-)	0	0	3	4	6	5	12
BIOTIN (H):		1985	1990	1991	1993	1995	1998
Roche	86	79	47	45	43	44	45
Sumitomo	11	14	18	17	19	18	20
Merck	3	7	8	10	8	7	16
Tanabe (1986-)	0	0	17	20	18	19	16
Lonza (1990-1996)	0	0	5	5	5	5	0
Cartel	100	100	95	97	93	93	97
E. Sung (1989-)	0	0	5	3	7	7	3
THIAMINE (B1):		1985	1990	1991	1992	1994	1998
Roche	46	55	49	44	36	38	48
Takeda	35	18	36	31	27	22	23
BASF (1982-)	0	7	0	2	0	0	1
Cartel	81	80	85	77	63	60 [c]	72
Grinsted (Roche 1981)[a]	7	0	0	0	0	0	0
China	9	14	12	20	32	40	28
India (1991-1993)	0	3	2	2	2	0	0
VITAMIN B12:	1985			1990	1995	1997	1998
Rhone-Poulenc	57	NA	NA	62	72	72	72
Hoechst (1968-)	10	NA	NA	7	9	10	9
Cartel	67			69	81	82	81
Glaxo (exit 1991)	16	NA	NA	12	0	0	0
Merck Co. (exit 1989)	11	NA	NA	0	0	0	0
Hungary	2	NA	NA	11	7	5	5
Nippon Petro. (1991-98)	0	NA	NA	0	5	3	1
China (enter 1995)	0	NA	NA	0	3	9	11
PYRIDOXINE (B6):		1985	1990	1991	1992	1994	1998
Roche	58	46	43	49	50	38	60
Daiichi	13	14	15	12	12	8	12
Merck (enter 1982)	0	15	10	5	0	0	1
Takeda	9	9	14	12	10	8	16
BASF (1982-1991)	0	11	8	3	0	0	0
Cartel	80	95	90	81	72	54 [c]	89
Grinsted (Roche 1981) [a]	13	0	0	0	0	0	0
China (enter 1986)	0	0	4	14	25	43	10
Pliva (Slovakia)	5	3	3	2	1	0	0
CANTHAXANTHIN:		1988	1990	1991	1997	1998	1998
Roche	83	87	87	85	76	68	68
BASF	17	13	13	15	24	32	32

Cartel	100	100	100	100	100	100	100
VITAMIN D3:	1982	1985	1989	1990	1995	1998	1998
Roche	57	57	60	43	41	40	40
Solvay	43	41	40	44	39	39	39
BASF (enter 1990)	0	0	0	13	21	21	21
Cartel	100	98	100	100	100	100	100
A.L. Labs (1983-1985)	0	0	0	0	0	0	0
FOLIC ACID (B9):	1987	1990	1990	1991	1993	1994 [c]	1998
Roche	34	41	41	39	32	31	41
Takeda	23	20	20	23	21	15	22
Sumika/Sumitomo	20	20	20	20	13	8	7
Kongo	16	15	15	15	10	5	0
Cartel	93	96	96	97	76	59 [c]	70
China	3	2	2	2	24	34	21
India	4	2	2	2	2	7	9

NA = Not available

Source: Bernheim (2002: Chapter 8) and EC (12/9/2004).

a) Grinsted was a Danish manufacturer with large shares in four vitamins industries. It was acquired in 1981 by Roche but apparently resold immediately to BASF.
b) Rhone stopped making human-grade vitamin E around 1990.
c) The Folic acid cartel fell apart in mid 1994, so the cartel's degree of market control was probably above 65% in the first half of 1994 and below 55% in the second half of 1994. In vitamins, B6 had the lowest degree of market control (54%), B1 the second-lowest degree of control (60%), and C the third-lowest degree of control (62%) in their last years.

Appendix Table 6A. Intra-Cartel Global Market Shares

	Years									
Product: Company	89	90	91	92	93	94	95	96	97	98
					Percent [a]					
VITAMIN E:										
Roche	- -	46.5	46.9	46.3	46.3	48.4	45.3	47.9	45.7	45.5
Rhone-Poulenc	- -	28.3	29.2	27.4	27.4	26.3	26.3	26.6	28.3	28.4
BASF	- -	13.1	12.5	14.7	13.7	12.6	15.8	14.9	14.1	13.6
Eisai	- -	12.1	11.5	10.5	10.5	11.6	11.6	11.7	12.0	11.4
VITAMIN A:										
Roche	- -	48.5	47.4	47.9	48.3	48.3	46.7	46.7	47.8	47.3
BASF	- -	30.3	30.9	31.3	30.3	30.3	31.2	20.4	31.5	31.9
Rhone-Poulenc	- -	21.2	20.6	20.8	21.4	21.4	21.5	21.7	20.7	20.9
VITAMIN C:										
Roche	- -	- -	51.7	53.3	50.7	51.5	51.6	- -	- -	- -
Takeda	- -	- -	29.2	32.0	31.0	30.9	30.7	- -	- -	- -
E. Merck	- -	- -	11.2	9.3	9.9	10.3	9.7	- -	- -	- -
BASF	- -	- -	19.0	6.7	8.5	7.4	8.1	- -	- -	- -
CHOLINE CHLORIDE:										
Mitsui	22	32	34	28	33	32	32	35	35	35
Chinook	30	25	28	33	36	38	38	39	37	27
DuCoa	49	42	37	39	32	31	31	28	26	26
BETA CAROTENE:										
Roche	- -	- -	82	75	84	77	74	75	75	74
BASF	- -	- -	18	25	16	23	26	25	26	26
VITAMIN B5:										
Roche	- -	- -	41.9	43.8	42.7	40.9	40.5	42.5	46.0	44.6
Daiichi	- -	- -	33.7	33.7	36.0	35.2	36.0	34.5	34.5	30.1
BASF	- -	- -	24.4	22.5	21.4	23.9	23.6	23.0	19.5	25.3
VITAMIN B3:										
Lonza	- -	- -	67.4	62.0	65.2	65.2	66.3	62.1	63.4	62.6
Degussa and Reilly	- -	- -	25.6	28.3	24.7	24.7	23.6	29.5	29.0	29.7
Napera	- -	- -	7.0	9.8	10.1	10.1	10.1	8.4	7.5	7.7
VITAMIN B2:										
Roche	- -	- -	62.1	54.6	52.4	48.9	44.7	- -	- -	- -
BASF	- -	- -	34.5	30.7	31.0	30.0	27.7	- -	- -	- -
Takeda	- -	- -	3.5[d]	14.8	16.7	18.9	18.1	- -	- -	- -
Rhone-Poulenc	- -	- -	0	0	0	2.2	9.6	- -	- -	- -
BIOTIN (H):										

Roche	- -	- -	46.9	45.7	46.2	45.7	47.3	- -	- -	- -
Sumitomo	- -	- -	17.7	20.2	20.4	17.4	19.4	- -	- -	- -
Tanabe	- -	- -	20.8	19.2	19.4	22.8	20.4	- -	- -	- -
E. Merck	- -	- -	10.4	9.6	8.6	8.7	7.5	- -	- -	- -
Lonza	- -	- -	4.2	4.3	5.4	5.4	5.4	- -	- -	- -
VITAMIN B1:										
Roche	- -	- -	57.1	57.1	55.7	63.3[b]	- -	- -	- -	- -
Takeda	- -	- -	40.3	42.9	44.3	36.7[b]	- -	- -	- -	- -
BASF	- -	- -	2.6[c]	0[c]	0[c]	0[c]	- -	- -	- -	- -
VITAMIN B12:										
Rhone-Poulenc	- -	89.9	91.1	89.5	89.3	89.3	88.9	88.9	87.8	- -
Hoechst	- -	10.1	8.9	10.5	10.7	10.7	11.1	11.1	12.2	- -
VITAMIN B6:										
Roche	- -	- -	59.8	69.4	64.0	70.4	- -	- -	- -	- -
Daiichi	- -	- -	14.6	16.7	18.0	14.8	- -	- -	- -	- -
E. Merck	- -	- -	6.1	0	0	0	- -	- -	- -	- -
Takeda	- -	- -	14.6	13.9	18.0	14.8	- -	- -	- -	- -
BASF	- -	- -	4.9	0	0	0	- -	- -	- -	- -
CANTHAXATHIN:										
Roche	- -	- -	85	85	80	79	77	77	76	68
BASF	- -	- -	15	15	20	21	23	23	24	32
VITAMIN D3:										
Roche	- -	43	41	45	42	41	41	40	40	40
Solvay	- -	44	43	39	40	40	39	38	39	39
BASF	- -	13	17	16	18	20	21	22	21	21
FOLIC ACID (B9):										
Roche	- -	42.7	40.2	41.1	42.1	52.5	- -	- -	- -	- -
Takeda	- -	20.8	23.7	23.2	27.6	25.4	- -	- -	- -	- -
Sumika	- -	20.8	20.6	20.0	17.1	13.6	- -	- -	- -	- -
Kongo	- -	15.6	15.5	15.8	13.2	8.5	- -	- -	- -	- -

- - = Non-cartel years

a) The annual market shares are given in whole percentages, so the figures in this table may show rounding errors.

b) This cartel in mid 1994, so the shares shown are a combination of conspiracy and non-conspiracy periods.

c) BASF dropped production at the beginning of the cartel in 1991 but resold almost one-fourth of Roche's production until mid 1994. Thus, BASF had a 14% global sales share.

d) Joined the next year.

Appendix Table 7. EU Fines, Vitamins Cartels, 2001 and 2004													
Company	A	B1	B2	B4	B5	B6		C	D3	E	Folic Acid	H	Total
	Million U.S. dollars												
Roche[b]	75.5	0[a]	37.1		47.7	0[a]	83.4	57.6	18.5	88.1	0[a]	0[a]	408.0
BASF[b]	40.8		16.7	46.6	30		75.1	13.0	6.7	79.3			308.1
Takeda			7.8			0[a]		25.0					32.7
Daiichi					20.7	0[a]							20.7
Akzo Nobel				28									28.0
UCB				13.8									13.8
Eisai										11.7		0[a]	11.7
E. Merck								8.2					8.2
Solvay									8.0				8.0
Rhone-Poulenc	0[c]								4.5	0[c]			4.5
Lonza												0[a]	0
Kongo		0[a]											0
Sumika		0[a]											0
Sumitomo												0[a]	0
Tanabe												0[a]	0
DuCoa				0[a]									0
Chinook				0[a]									0
TOTAL	116.3	0[a]	61.5	88.4	98.4	0[a]	158.6	103.7	37.7	179.1	0[a]	0[a]	843.6
	a) Companies are guilty but stopped colluding more than 5 years before investigation began b) Fines reduced by 50% for early cooperation with EC c) Fines reduced by 100% for first to cooperate (amnesty)												

[CHECK TABS A8-A9]

Appendix Table 10 Settlements by Private Parties, Vitamins Cartels, 2000-2006

Plaintiff	Products	Defendants	Amount
			$ million
3900 direct U.S. buyers, opt-ins (24% of plaintiffs' sales)	A, B1, B2, B5, C, B6, B9 (folic acid), B12, E, beta carotene, canthaxanthin, astaxanthin, biotin (H), premixes	Roche BASF Aventis Takeda Eisai Daiichi	} 325
200 direct U.S. buyers, opt-outs (76% of plaintiffs' sales)	A, B1, B2, B5, C, B6, B9 (folic acid), B12, E, beta carotene, canthaxanthin, astaxanthin, biotin (H), premixes	Roche BASF Aventis Takeda Eisai Daiichi	} 3,400-4,700
Direct buyers ($131 million affected U.S. sales)	Choline Chloride (B4) Choline Chloride (B4) Choline Chloride (B4) Choline Chloride (B4)	BASF Akzo UCB DuCoa and Mitsui	5.0 7.5 9.0 53.0
Direct U.S. buyers (<$100 million sales)	Vitamin C (not including Big Six)	E. Merck	50.0
Direct U.S. buyers ($33.4 million sales)	Biotin (vitamin H) Biotin (vitamin H)	Sumitomo Tanabe	17.5 45.0
Direct U.S. buyers ($104 million sales)	Vitamin B3 (niacin) Vitamin B3 (niacin) Vitamin B3 (niacin) Vitamin B3 (niacin)	Reilly Lonza Degussa Nepera	4.2 27.2 8.6 3.5
Direct Canadian buyers	A, B2, B3, B4, B5, B12, C, E, H, premixes, and 2 provitamins	All except Solvay, Kongo	105
Direct Australian feed-grade buyers	Unknown	Big Three	37
Indirect buyers in 23 states (NAAG suit) and direct by states	Major vitamins	Big Six	305
		Known TOTAL	4347-5722

Sources: Boies (2004), Denger (2005), Ontario Superior Court of Justice (3/23/2005), NAAG press releases, and other settlement announcements.

Appendix Table 11. U.S. Vitamins Overcharges by Defendant

Company	Opt-Outs	Federal Class	Total
	million US dollars		
Roche	479	594	1073
BASF	253	243	496
Rhone-Poulenc	67	82	149
Eisai	46	35	81
Takeda	14.7	67	81.7
Daiichi	8.9	10.9	19.8
Merck	2.9	18.1	21
DuCoa	31.4	13.7	45.1
Bioproducts	23	21.5	44.5
Chinook	37.7	9.8	47.5
Lonza	5.0	7.1	12.1
Degussa	39	3.1	7
Nepera	0.6	1.1	1.7
Reilly	0.2	1.4	1.6
Sumitomo	11.5	5.2	16.7
Tanabe	0.5	1.5	2
Hoechst	0.5	3.5	4
Solvay	0.05	0.01	0.06
Total of 18	$986.0	$1,117.3	$2,103.3[a]

Note: Missing are UBC, Akzo (European B4 cartel).

Source: Bernheim (2002a: 19).

a) Total $ 2002 damages are $1,643 + $1,864= $3,507 (from 1985 total is $3,972).

Appendix Table 12. Affected Sales, by Defendant and by Product, 1990-1999					
PRODUCT: Company	U.S.	Canada	EU	Rest of World [a]	Total
	Million current U.S. dollars				
VITAMIN A:	824	58	1519	651	3052
Roche	433	24.4	653	202	1312
BASF	103	7.0	441	304	855
Rhone-Poulenc	227	24.4	334	25	610
Cartel	799	55.7	1397	525	2777
VITAMIN B1:	50	7	102	79	238
Roche	13.8	1.5	53	18	86
BASF	0	0	16	0	16
Takeda	16.3	2.3	29	17	64
Cartel	30.1	3.9	91	40	166
VITAMIN B2:	138	11	234	93	476
Roche	59	5.4	108	37	209
BASF	31	1.7	68	28	129
Takeda	24	2.2	30	25	81
Rhone-Poulenc	0	0	0	5	5
Cartel	114	9.1	206	94	424
VITAMIN B3:	267	8	250 [e]	260 [e]	785
Lonza	91	6.3	171	187	455
Degussa	59	0.25	55	4	118
Reilly	29	0.25	20	6	55
Nepera	75	0.25	0	0	77
Cartel	254	7.6	246	197	705
VITAMIN B4:	529	43.9	343.4	550	1466.3
Chinook	175	35.6	0	72	283
Mitsui	149	2	0	28	179
DuCoa	144	2	0	93	239
BASF	14.0[c]	1.0[c]	114	4	147
Akzo Nobel	21.7[c]	1.5[c]	105.8	47	198
UCB	25.3[c]	1.8[c]	77.9	91	221
Cartel	529	43.9	297.7	336	1268
VITAMIN B5:	184	11	308	72	575
Roche	60	3.6	136	13?	213
BASF	23	3.3	92	0?	115
Daiichi	97	3.6	37	35	173
Cartel	179	10.5	264	46	500

VITAMIN B6:	54	15	73	103	245
Roche	13.0	0	37	73	123
Daiichi	6.8	6.5	6	11	29
Takeda	9.7	2.0	8	5	25
Cartel	30	8.5	51	86	176
VITAMIN B12:	112	2	150 [e]	203 [e]	467
Rhone-Poulenc	81	1.5	128	125	336
Hoechst	8	0.1	15	19	42
Cartel	90	1.6	143	143	378
VITAMIN C:	1027	72	1155	1414	3668
Roche	485	39	589	171	1284
BASF	26	5	127	25	183
Takeda	320	15	92	343	770
E. Merck	62	2.9	92	100	257
Cartel	892	62	900	640	2494
VITAMIN D3:	72	5 [e]	98	65	240
Roche	29	2.0	31	36	98
BASF	8	0.6	20	21	50
Rhone-Poulenc	13	0.9	10	0?	24
Solvay	22	1.5	37	33	94
Cartel	72	5	98	65	240
VITAMIN E:	1658	111	2177	791	4737
Roche	788	41	870	433	2132
BASF	373	12.2	588	211	1184
Rhone-Poulenc	290	49	326	0?	663
Eisai	207	6.7	239	0?	521
Cartel	1658	109	2023	710	4500
FOLIC ACID (B9):	11.5	2	19.5 [e]	5 [e]	38
Roche	1.4	0.25	7.0	3.6	12.2
Takeda	3.2	0.55	4.0	0.2	8.0
Kongo	2.2	0.4	1.8	0?	3.8
Sumika/Sumitomo	2.4	0.4	4.0	0?	4.9
Cartel	9.2	1.6	16.8	3.8	31.4
BIOTIN (H):	144	2	128	206	480
Roche	58	0.8	48	99	206
BASF	0	0	8	0	0
Lonza	27	0.4	10	0?	24

E. Merck	9	0.1	6	23	38
Sumitomo	30	0.4	15	46	91
Tanabe	20	0.3	34	32	86
Cartel	144	2	120	180	446
BETA CAROTENE:	392	24	571	201	1188
Roche	380	16.6	371	183	879
BASF	12	7.4	200	90	309
Cartel	392	24	571	201	1188
CANTHAXANTHIN:	116	1	490	1050	1657
Roche	116	0.98	372	770	1259
BASF	0	0.02	118	280	398
Cartel	116	1	490	1050	1657
VITAMIN PREMIXES:	2040	174	2625	2447	7286 [e]
Roche	632	54	1050 [e]	814	2550
BASF	388	33	525 [e]	174	1093
Cartel	1020	87	1575	961	3643
TOTAL OF 16	7619 [c]	547 [c]	10243	8192	26,601

Sources: Appendix Tables 1 and 5.
- - Not applicable (no known sales).
a) A residual column. Total only approximate.
b) No production, but sales quotas in some regions.
c) Includes estimated imports
e) estimated

Appendix Table 13. Overcharges, by Defendant and by Product, 1990-1999

PRODUCT: Company	U.S.	Canada	EU	Rest of World [a]	Total
	Million current U.S. dollars				
VITAMIN A:	270.3	19.0	403	240	932.3
Roche	142	8.0	173		400.9
BASF	33.8	2.3	117		261.0
Rhone-Poulenc	74.3	8.0	89		176.5
Cartel	260.1	18.2	371	198.2	848.4
VITAMIN B1:	9.1	1.27	6.6	11.7	28.7
Roche	2.5	0.28	3.4		10.3
BASF	0	0	1.1		0
Takeda	3.0	0.42	1.8		7.7
Cartel	5.5	0.70	6.3	5.6?	18.1
VITAMIN B2:	31.7	2.53	62.0	27.6	123.8
Roche	13.5	1.24	28.5		54.5
BASF	7.1	0.38	18.0		33.4
Takeda	5.5	0.51	8.1		21.0
Rhone-Poulenc	0	0	0		2.5
Cartel	26.1	2.13	54.6	28.6?	111.4
VITAMIN B3:	41.7	1.25	39.0	40.6	122.6
Lonza	14.3	0.99	27.3		71.1
Degussa	9.2	0.08	8.6		18.4
Reilly	4.6	0.03	3.1		8.6
Nepera	11.7	0.10	0		11.0
Cartel	39.7	1.20	39.0	29.2?	109.1
VITAMIN B4:	157.7	13.5	137.5	185.4	494.1
Chinook	72.5	12.0	?		95.4
Mitsui	48.9	0.7	?		60.3
DuCoa	23.7	0.7	?		80.5
BASF	?	?	43.2		45.0
Akzo Nobel	?	?	43.3		59.3
UCB	?	?	37.8		66.2
Cartel	145.1+	13.4+	124.4	124.1?	407
VITAMIN B5:	57.0	3.41	130.9	31.8	223
Roche	18.5	1.13	57.6		82.5
BASF	7.1	1.02	39.3		44.6
Daiichi	29.9	1.13	15.7		66.9
Cartel	55.5	3.28	112.6	22.6	194

VITAMIN B6:	13.0	3.60	31.0	41.1	88.7
Roche	3.3	0	15.8		44.4
Daiichi	1.6	1.55	2.5		10.6
Takeda	2.3	0.47	3.4		8.9
Cartel	7.2	2.02	21.7	33.0	63.9
VITAMIN B12:	50.1	0.89	67.1	108.8	226.9
Rhone-Poulenc	37.0	0.66	57.0		163.4
Hoechst	3.5	0.06	6.7		20.4
Cartel	40.6	0.72	63.7	78.8	183.8
VITAMIN C:	242.4	17.0	289	413	961.4
Roche	116.4	9.2	147.4		336
BASF	7.3	1.2	31.8		48
Takeda	76.4	3.6	23.1		202
E. Merck	14.5	0.7	23.1		67
Cartel	214.6	14.6	216.8	207?	654
VITAMIN D3:	9.7	0.68	10.8	9.6	30.8
Roche	3.9	0.27	3.0		12.6
BASF	1.1	0.07	2.2		12.0
Rhone-Poulenc	1.7	0.12	1.1		0
Solvay	2.9	0.20	4.1		6.5
Cartel	3.6	0.67	10.4	10.1?	30.8
VITAMIN E:	641.6	43.0	1,089	421	2,194.6
Roche	305	15.9	381		988
BASF	144	4.7	272		549
Rhone-Poulenc	112	18.9	218		307
Eisai	80	2.6	136		241
Cartel	641	42.1	1,007	395	2,085
FOLIC ACID (B9):	2.6	0.45	12.5	1.34	16.9
Roche	0.33	0.06	4.4		5.4
Takeda	0.70	0.12	2.5		3.5
Kongo	0.49	0.08	1.1		2.2
Sumika/Sumitomo	0.55	0.09	2.5		1.7
Cartel	2.08	0.36	10.5	0?	12.8
BIOTIN (H):	25.2	0.35	19.8	46.6	92.0
Roche	10.1	0.14	7.3		39.6
BASF	0	0	1.2		0
Lonza	4.8	0.07	1.6		4.6
E. Merck	1.5	0.02	1.0		7.4
Sumitomo	2.3	0.07	2.4		17.5

Tanabe	3.5	0.05	5.1		16.6
Cartel	25.2	0.35	18.6	41.4	85.6
BETA CAROTENE:	120.3	7.37	176	74.0	377.7
Roche	117.3	5.09	114.4		283.3
BASF	3.0	2.28	61.6		94.4
Cartel	120.3	7.37	176.0	74.0	377.7
CANTHAXANTHIN:	22.5	0.190	95.1	245	362.8
Roche	22.5	0.186	95.1		275.7
BASF	0	0.004	0		87.1
Cartel	22.5	0.190	95.1	245	362.8
VITAMIN PREMIXES:	601.8	51.3	774	866	2293
Roche	186.6	15.9	31.0		688
BASF	114.3	9.7	15.8		459
Cartel	300.9	25.6	465	355?	1147
TOTAL OF 16	2,296.7	160.5	2,722	2,810	7,989

Sources: Tables 12, 13, 14, and 15 and Appendix tables 1, 5, 6, and 12.
? Not applicable (no known sales).
e = Estimated.
a) A residual column. Total only approximate.
b) No production, but sales quotas in some regions.
c) From Appendix Table 6 (shares in peak price year).

Appendix Table 14. Maximum and Actual U.S. Corporate Fines					
Date of Plea	Company (Product)	Maximum [a]	Paid	Discount	Individuals
		Million current U.S. dollars		*Percent*	*Number*
July 1998	Bio-Products/Mitsui (B4)	97.8	0 [b]	100	
Sept. 1998	Lonza	38	10.5	72	
Feb. 1999	Rhone-Poulenc	450	0 [b]	100	
May 1999	Hoffmann-La Roche	2624	500	81	4 [f]
	BASF	818 [d]	225	72	4
Sept. 1999	Takeda	176	72	59	
	Eisai	160	40	75	
	Daiichi	63	25	40	
	Chinook (B4)	145	5 [c]	97	2 [f]
May 2000	E. Merck (C)	32	14	44	
	Degussa (B3)	18.4	13	29	
	Nepera (B3)	23.4	4 [c]	83	2
	Reilly (B3)	10.0	2	78	
Sept. 2000	DuCoa (B4)	47.4	0.5 [c]	99	4
None	Hoechst (B12)	10.0	0	100	
	Akzo Nobel (B4)	10.0	0	100	
	UCB (B4)	10.0	0	100	
	Solvay (D3)	10.0	0	100	
	Sumitomo (folic & biotin)	10.0	0	100	
	Tanabe (biotin)	10.0	0	100	
	Kongo (folic acid)	10.0	0	100	
	(Other carotenoids)	45.0	0	100	
All	Total of 13 companies	4,773	911	81	16 [f]

Source; Appendix Tables 2 and 13.
a) If above $10 million, double the harm in the United States; otherwise the $10 million statutory cap.
b) Full amnesty
c) Ability to pay probably an issue.
d) Includes $10 million for agreeing to stop selling in the U.S. market 1992-1998.
f) Russell Cosburn was found guilty in Canada but not in the United States; three Roche officers were convicted in both countries.

Appendix Table 15. Mileposts in the Discovery and Use of Vitamins, 1795-2001.	
Year	Event
1795	British Admiralty decrees a daily ration of lemon or lime juice for all seamen on long voyages to prevent scurvy.
1800s	Already a folk remedy for hundreds of years in northern Europe, clinical studies begin to confirm a range of health benefits of fish-liver oil, later found to contain the oil-soluble vitamins A, E, and D. Extraction of the oils becomes a major by-product of cod fisheries in Canada, Norway, and elsewhere.
1846	Justus von Liebig demonstrated that all living things were composed primarily of carbohydrates, fats, and proteins.
1861	An Austrian physician publishes a controlled experiment that demonstrated that night blindness can be cured by dietary liver extracts.
1862	Choline chloride is isolated from bile.
1867	Nicotinic acid, one form of vitamin B3, is identified by Huber, but its nutritional value is not discovered until 70 years later.
1886	The Dutch dispatch a medical team to discover the cause of beriberi in Indonesia.
1889	The team discovers that unpolished rice will prevent beriberi.
1905	German biochemist Stepp proves the existence of the class of fat-soluble vitamins.
1911	Polish biochemist Casimir Funk coins the term “vitamins.”
1912	Japanese biochemists extract a compound from rice hulls that prevents beriberi. U.S. biochemists discover a fat-soluble nutrient in butter and egg yolks whose absence causes mice to die prematurely. Funk proposes the vitamin-deficiency theory of certain diseases.
1914	Joseph Goldberger proves that pellagra is due to a dietary deficiency.
1915	The fat-soluble nutrient is named vitamin A by E.V. McCollum of the University of Wisconsin. Vitamin A is later shown to be essential for protein metabolism.
1916	A group of water-soluble vitamins (later named B) is isolated by U.S. chemist E.V. McCollum.
1918	English researcher Edward Mellanby demonstrates that cod liver oil cures rickets, long a folk remedy in the North Sea area. Yale biochemists L.B. Mendel and B. Cohen show that ascorbic acid deficiency causes scurvy in guinea pigs.
1919	Mellanby shows that rickets is caused by a vitamin deficiency.
1920	British biochemist J.C. Drummond names three vitamin groups A, B, and C; he also discovers that carotene can be converted to vitamin A by the human liver.
1921	U.S. embryologist finds the first evidence that a vitamin plays a role in animal reproduction.
1922	E.V. McCollum isolates vitamin D and successfully treats rickets. Vitamin E is discovered.
1923	Univ. of Wisconsin biochemist Harry Steenbock discovers that ultraviolet light can increase the vitamin D in foods.
1924	Boston physicians show that eating liver prevents pernicious anemia. Barnett Sure at the University of Arkansas showed that vitamin E deficiency interrupts reproduction in rats.
1926	Research begins to establish that the B vitamin is actually several. The first is named B1. Animal experiments find a relationship between pellagra and a vitamin B deficiency.
1927	Steenbock assigns his patent concerning vitamin D irradiation to the Wisconsin Alumni Research Foundation.
1928	Vitamin C is isolated from capsicum peppers at a Cambridge, England laboratory. Eli Lilly Co. introduces a commercial vitamin extract from livers to treat anemia.
1929	T. Moore proves that yellow carotene is the precursor of retinol in the eyes of animals. Five years later, researchers would establish that retinol (vitamin A) is essential to vision.

Appendix Table 15. Mileposts in the Discovery and Use of Vitamins, 1795-2001.	
Year	Event
1930	A crystalline form of vitamin D is isolated and within three years is being used to fortify butter, margarine, and milk products.
1931	Swiss chemist Paul Karrer isolates vitamin A. Roche begins marketing an extracted natural vitamin B1.
1932	University of Pittsburgh biochemist C. G. King synthesizes vitamin C.
1933	Cambridge University biochemist P. György discovers vitamin B6, a coenzyme that cures dermatitis, and isolates vitamin B2. Vitamin C is named ascorbic acid and is chemically synthesized one year later by T. Reichstein. Pantothenic acid (vitamin B5) is isolated by Williams.
1935	Researchers at Germany's Kaiser Wilhelm Institute, building on research published in 1932, synthesize vitamin B2 (riboflavin). Roche begins synthetic vitamin B2 production in the late 1930s. University of California at Berkeley biochemist H. Evans isolates Vitamin E from wheat germ oil. St. Louis researchers isolate vitamin K, which is essential for blood coagulation. Biotin is discovered.
1936	University of Wisconsin biochemist C. A. Elvehjem isolates vitamin B3 (niacin) and shows that it cures pellagra. R. R. Williams synthesizes vitamin B1 (thiamin). Vitamin A is synthesized. New York entrepreneurs found a company to market Vitamins Plus, the first commercial vitamin-mineral dietary supplement. Roche begins commercial production of vitamin C using the Reichstein process, which originally required 17 steps of synthetic chemistry.
1937	German biochemists K. Lohmann and P. Schuster discover the biological process whereby vitamin B1 prevents beriberi. Williams synthesizes vitamin B1. Roche and U.S. manufacturers introduce synthetic vitamin B1 to the market at about $450 per pound.
1938	U.S. biochemist R.J. Williams synthesizes vitamin B5 (pantothenic acid). P. Karrer, working at Hoffmann-La Roche, synthesizes vitamin E and finds it to be an antioxidant. Roche holds a vitamin E monopoly until 1967. Scientists propose enrichment of bread with vitamin B1. Lonza began production of niacin this year or in 1940, but other petrochemical companies may have preceded Lonza. Enrichment of bread with vitamin B3 begins.
1939	Roche first produces synthetic vitamin E. US researchers identify the chemical structure of pyridoxine, one of six forms of vitamin B6, and synthesize it.
1940s	Merck & Co. begins small scale commercial production of natural vitamin B2 using its patented fermentation process.
1940	U.S. biochemist V. Vigneaud isolates biotin (sometimes vitamin H). Choline chloride is shown to prevent perosis, a leg disorder in turkeys; vitamin B4 (or B7) is still used mainly as a poultry feed supplement. Vitamin B5's structure is identified.
1941	30 percent of all U.S. bread is being enriched with vitamin B1.
1942	H. Dam in the Netherlands identifies the chemical structure of vitamin K. One form of vitamin K is synthesized one year later. Cornell University scientists discover the chemical structure of biotin.
1943	The Food and Nutrition Board of the National Academy of Sciences publishes Recommended Daily Allowances (RDAs) of various nutrients (including vitamins) for the first time. Enrichment of bread with vitamin B3 becomes mandatory in the United States.
1944	U.S. biochemists H. Mitchell and E. Snell isolate folic acid, later found to cure macrocytic anemia. The U.S. War Food Administration mandates vitamin B enrichment of bread and pastries.
1945	Biotin is synthesized in Merck & Co. labs, but Merck is never a significant producer.
1946	Roche begins vitamin B5 production. Takeda initiates vitamin B1 production.
1947	Roche begins biotin production.

Appendix Table 15. Mileposts in the Discovery and Use of Vitamins, 1795-2001.	
Year	Event
1948	Vitamin B12 is isolated, but understanding its chemistry will take eight years of further research; it is shown to cure pernicious anemia. This is the last of the 13 vitamins considered to be essential for human health to be isolated. Merck & Co. becomes the first company to introduce vitamin B12 to the market, but ends production in the late 1980s as Rhone-Poulenc overtakes it.
1949	Roche begins commercial production of vitamin A and retains its monopoly until 1969.
1950s	The first cost-effective method of making vitamin D3 is developed, replacing extraction from fish liver oils.
1953	Researchers at Basel, Switzerland synthesize beta carotene.
1954	Roche scientists develop a method for synthesizing beta carotene. Roche starts production.
1958	Alps Pharma of Japan becomes second producer of vitamin B5.
1959	Predecessor of Daiichi begins vitamin B5 production in Japan. Eisai begins vitamin E production in Japan.
1964	Beta carotene is approved for use as a colorant in foods. Roche begins making canthaxanthin.
1967	Eisai ends Roche's monopoly in both the animal- and human-grades of vitamin E and begins exports to Europe.
1970	Nobel prize winner Linus Pauling writes a popular book that recommends megadoses of vitamin C to cure the common cold, joining a lengthening list of popular writers who make unsupported claims about the health benefits of excessive vitamin consumption. The FDA begins to develop rules to regulate megadoses of vitamins, but in 1973 Sen. William Proximire spearheads a new law that frees dietary supplements from government regulation.
1970	BASF enters the animal-grade vitamin A market, ending Roche's monopoly. Sumitomo enters biotin production.
1972	BASF becomes the second manufacturer of beta carotene and the third manufacturer of animal-grade vitamin E in Germany.
1970s	BASF enters the human-grade vitamin A market, ending Roche's monopoly.
1984	Roche starts production of astaxanthin.
1987	Roche begins folic acid production, long dominated by Takeda, Sumitomo, and Kongo.
1988	Chinese production of vitamin C begins using a one-step fermentation method.
1990	Lonza enters the biotin market through the acquisition of Cyclo Products Inc. BASF begins production of vitamin B2 on a large scale using the Merck & Co. fermentation process; it discontinues production of synthetic vitamin B2 in 1996.
1994	Three major scientific studies of vitamins-health relationships are published. They found that large doses of vitamins A, B3, C, and E were either toxic or ineffective in reducing cancer or heart disease.
1998	Eisai opened its second synthetic vitamin E plant in Texas, but closes it in 2001.
Sources: Tannahill (1988), Hui (1992), Trager (1995), Bernheim (2002a), EC (2001), and Kiple and Ornelas (2000).	