Chapter 4: The Citric Acid Industry

Citric acid is a product found in thousands of grocery products. This chapter answers the following questions: what is citric acid used for, who makes it, how do they make it, how much is made, and where is it made?

The Product

Citric acid is an organic chemical with a unique molecular structure. As an additive in foods like yogurt, sausages, and soft drinks, citric acid is one of several acidulents purchased by food manufacturers. Acidulents serve several useful functions in food formulations: sterilization, bacterial stabilization, flavor fixation, flavor enhancement, and standardization of acid levels. Besides its uses in the food industries, approximately one-third is purchased by detergent manufacturers. Citric acid has been replacing phosphorus in detergents because it does less harm to the ecology of rivers and lakes. Although there are about six other commercially important acidulents, citric acid accounts for more than 80 percent of the value of all acidulents sold in the U.S. market.[1] In most food and beverage formulations, citric is the only feasible acid.

Technology and Early Development

Citric acid may be manufactured in three ways. The oldest method extracts the acid from citrus fruits. In the early 19th century, a cheaper method of making citric acid by chemical synthesis of calcium citrate was put into commercial production in the United Kingdom. However, because the calcium citrate was mainly extracted from Italian lemons, the industry had

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1 Except for the substitution of citric acid for phosphorus in detergents, the uses of various acidulents appear to be very stable. That is, the demand for acidulents tends to grow with the demand for the foods and beverages in which they are mixed. The largest use of citric acid is in soft drinks of all kinds (*Chemical Market Reporter* June 3, 1991).

become an Italian monopoly by the turn of the century.[2] U.S. production by chemical synthesis began around 1880 by the firm Charles Pfizer, Inc., the predecessor of today's Pfizer, Inc.

The dislocation of Italian citric acid production caused by World War I forced prices to very high levels in the early 1920s. The high prices provided an incentive to search for a new method of production that would not require calcium citrate as a feedstock. Chemical experiments in the late 19th century had already shown that traces of citric acid were produced when the *Penicillin* mold was grown in sugar solutions. In 1917, an American chemical scientist published a paper that reported that a different mold, *Aspergillus niger*, produced large amounts of citric acid when it metabolized in a solution of sucrose, salts, and iron. Within six years, this discovery had been put into commercial production by Charles Pfizer, Inc. in its Brooklyn, New York plant. This 1923 manufacturing venture may have been the first commercially successful true biotechnology-based industry. The new technology broke the Italian monopoly on calcium citrate.

Production using the Pfizer fermentation process spread to Europe in the 1930s, starting with a factory in the UK. Fermentation plants using beet sugar molasses were built in Germany, Belgium, and Czechoslovakia. In the post-World War II period, more improvements were made: submerged cultures, higher-yielding yeast strains, and the substitution of glucose for sucrose. Pfizer developed the "shallow pan" fermentation process that had become the industry standard by the 1980s.[3] Production of citric acid spread to China in the early 1970s, utilizing sweet potatoes or cassava in small-scale fermentation units.

Citric acid is sold in two product forms and in two quality grades. The two forms are anhydrous and monohydrate. The anhydrous form consists of sodium citrate, potassium citrate, or other salts of citric acid. Citric salts are ideal for most non-food industrial uses such as detergents, where standards of purity are not as high as citric acid to be used in foods or beverages. Most producers of citric acid salts make both quality grades, but until the 1990s, much of the citric acid being exported from China did not meet food-grade standards. Most citric acid shipped internationally is sent in dry form to save on transportation costs, but some citric acid is sold for delivery in liquid solutions.

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2 A profile of the development of the citric acid industry appeared in the British newspaper, *The Independent* on March 9, 1992. This source attributes the discovery of chemical synthesis of citric acid from calcium citrate to John and Edmond Sturge, and dates commercial manufacture in their Selby, Yorkshire plant from 1826. Pfizer's early role is given in *Chemical Market Reporter* July 9, 1990.

3 Miles developed the "deep tank" method in the 1950s. A fourth technology that applied yeast fermentation to petroleum-derived n-alkanes was proved to be technologically feasible in the 1960s. In 1975, Miles Laboratories formed a joint venture with Liquichemica Biointensi, but the venture was never profitable. (*Chemical Week*, November 12, 1975).

Market Size and Growth

Market size can be measured at least four ways (see Box). In this section, the focus is on consumption of citric acid and on growth in its demand. The next section discusses industry capacity and supply figures.

Market Size

The total size of a market is indicated by *industry capacity*, *production*, *product demanded* or *consumed*, or *sales*. The first three concepts of size are measured in physical units of weight or volume such as pounds, kilograms, or tons. Sales are the summation of buyer-seller transactions over a period of time, measured in monetary units. Capacity and production are supply-side concepts, whereas consumption views a market from the buyers' perspectives. Sales can be either the total revenues of sellers in a market or the total procurement expenses of buyers.

In manufacturing industries capacity is measured by the maximum or optimal production possible from all plants in a given time period. The most common measure is the annual engineering-design capacity of a plant sometimes called nameplate capacity. This ideal notion of capacity assumes that a plant will operate 24 hours a day for 365 days per year at the maximum levels envisioned by the plant's designers. In practice, plants being operated at full capacity normally require at least 15 to 30 days of down time each year for cleaning or repairs. Thus, maximum feasible production is typically 90 to 95% of nameplate capacity. Moreover, the most profitable level of production for a plant (i.e., optimal capacity) is usually somewhat lower than the maximum feasible levels of operation. In most manufacturing industries, during periods of strong demand, plants optimally utilize about 80 to 90% of their nameplate capacity.

For a non-storable commodity, global production will be equal to global consumption. Citric acid, lysine, and vitamins are storable products, so production will exceed consumption only if manufacturers or buyers are building up their inventories. On an annual basis, global production and consumption are likely to be virtually identical. However, regional production and consumption frequently diverge because some regions are net exporters and other regions are net importers.

Global sales are typically the most difficult indicator of market size to measure accurately because of corporate secrecy and multiple national price levels and currencies. In many markets only list prices are public knowledge. List prices rarely equal the transaction prices needed to calculate accurate sales figures. Moreover, sales figures are highly sensitive to the price levels used. Prices may be f.o.b. plant, delivered prices by manufacturers; prices charged by wholesale distributors, or retail prices.

Manufacturers of specialty chemicals like citric acid often have only vague notions about the amount of aggregate production or consumption in their industry. Industry trade magazines faithfully report press releases of plant constructions and expansions, national trade data, or other indicators of industry size, but these publications rarely take the trouble to resolve contradictory information. Proprietary reports by management consultants on an industry's size or growth are sold to a limited number of clients, sometimes summarized for public consumption. Where they exist, national industry trade associations often collect their members' production figures to arrive at national industry totals. However, these efforts often vary widely in terms of reliability and are of limited use when the industry is global in scope. Moreover, when a national industry consists of only two or three producers, a national trade association is unlikely to be established. In short, manufacturers themselves are often in the dark about their national or global market shares, changes in those shares, and rates of growth in consumption or production.

The trade press contains only about a half dozen references to the amounts of citric acid consumed by industrial buyers in the United States and only a couple of estimates of global consumption (Connor 1999b). More reliable and comprehensive sales and capacity data can be found in EC (2002) and USITC (2002).

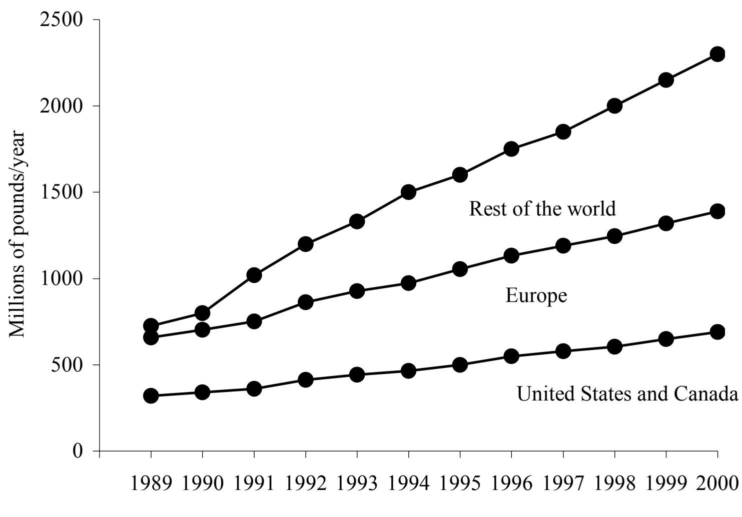

Figure 4.1 Global Consumption of Anhydrous Citric Acid, 1989-2000

Taking 1989 as the base year, U.S. consumption of citric acid was almost 300 million pounds (Figure 4.1). By 1996, U.S. demand reached 435 million pounds. Thus, demand was growing by about 6 percent per year in the early 1990s. That is about three times faster than the volume growth of the average food ingredient industry. This high rate of growth was being propelled by new uses in food and beverages and by the substitution of citric acid for phosphates by detergent makers.

The North American market was a large, but declining proportion of global demand for citric acid. U.S. and Canadian consumption of citric acid accounted for about 41% of global purchases in 1989 and 31% in 1996 (Connor 2001: Table 4.A.2). Europe was an equally large market for citric acid, accounting for 47% in 1989 and 28% in 1996. Global growth in citric acid demand was 10% per year in the 1990s. Growth of demand was slowest in Europe and in the United States but well above average in Asia and Latin America. Differences in demand growth are largely attributable to regional differences in consumer demand for beverages.

The Structure of Production

The North American Market

Until 1989, production of citric acid had been for decades a duopoly in the United States. The oldest American manufacturer, Pfizer, Inc., had long before closed its original Brooklyn plant and replaced it with a medium-size plant in Groton, Connecticut. Pfizer's most modern plant was located in Southport, North Carolina. This plant had a rated citric acid capacity of 80 million pounds per year. Pfizer also operated two small citric acid facilities in Canada and Ireland.

Pfizer's only domestic rival in the North American market was Miles Laboratories, which was headquartered in Elkhart, Indiana and was owned by Bayer Corporation. In terms of production characteristics, Miles was nearly a twin of Pfizer. Miles too had two U.S. citric acid plants, one in Elkhart that was rated at 90 million pounds and a smaller facility rated at 35 million pounds in Dayton, Ohio (Anon. 2001). Pfizer's U.S. plants were *finishing* facilities only. That is, they purchased their feedstock (dextrose) from independent producers. On the other hand, Bayer's Elkhart facility made its own dextrose and the Dayton, Ohio plant was supplied by a co-located Cargill corn wet milling plant.

Table 4.1 U.S. Market Shares of Leading Citric Acid Suppliers, Selected Years 1988-1998.

Sources of Supply	1988	1991	1995	1998
U.S. Manufacturing Capacity:		*Percent*		
Bayer/Haarmann & Reimer	42	41	28E	0
Pfizer or ADM	42	38	34E	40
Cargill	0	12E	30E	29
Tate & Lyle/A.E. Staley	0	0	0	12
U.S. Imports:[a]				
Hoffmann-La Roche	4	3	2	5
Jungbunzlauer	4	3	3	5
Other importers	6E	3E	3E	10
Subtotal of Top 5 Companies	94	97	97	90
Total Supply [b]	100	100	100	100

Source: Tables 1 and 2 of Connor (1998) and HRA (1992).
E = Estimates by author.
[a] Assumed that Roche accounted for all imports from Belgium and Jungbunzlauer from Germany and Austria where their plants were located. Other imports originated mainly from Italy, Israel, and China.
[b] The total of nameplate finishing capacities of plants located in the United States and U.S. import quantities. A small share of U.S. production was exported to Canada, so the shares shown correspond to U.S. and Canadian shares. Pfizer had a small plant in Canada, not included in the table that was closed by 1990.

Pfizer's and Miles' U.S. plants gave each of them slightly more than 40% of the U.S. supply of citric acid (Table 4.1). "U.S. supply" refers to the theoretical maximum production capacities of the four U.S. plants plus net imports of citric acid. In fact, a small share of U.S. production (about 5 to 10% in most years) was exported, to Canada primarily. Taking into account these exports and the fact that U.S. production was less than rated plant capacities, Pfizer and Miles each had U.S. *sales* shares of about 38% in 1988, with the remaining quantity sold (23%) being supplied by importers. The two largest importers were the large diversified chemical company Hoffmann-La Roche and the more specialized Jungbunzlauer. Roche operated a large citric acid plant in Tienen, Belgium from which it exported to the North American market. In citric acid Jungbunzlauer was even larger than Roche; it operated two or three large facilities in Germany, France and Austria. The remaining U.S. imports came from a number of countries, primarily China, Italy, and Israel.

In 1990, two important changes in the U.S. industry took place. The largest U.S. agribusiness firm, Cargill, began production of citric acid from a new plant that it had built at its existing corn wet milling plant at Eddyville, Iowa. Cargill had announced its intention to construct the new finishing facility in November 1987. The highly automated plant required merely 25 to 30 new employees and yet had a rated design capacity of 55 million pounds. What was unusual about Cargill's new plant was the fact that it was physically integrated with Cargill's existing corn wet milling plant. The add-on finishing facility reportedly cost only $40 million to build. When production began in the spring of 1990, the plant added 17% to the existing capacity of U.S. production. Cargill's substantial financial resources allowed it to expand its Iowa plant to 80 million pounds in 1991 and to 160 million in 1993.

The second important event in 1990 was ADM's entry into the industry. First signaling its intention to enter with a new plant in early 1990 about the time Cargill's plant was coming on stream, ADM then surprised the industry by announcing in August 1990 that it had agreed to purchase Pfizer's citric acid plants and technology instead of building a new plant. The purchase included Pfizer's Irish and North Carolina plants, with rated capacities of 20 and 100 million pounds. In addition, Pfizer agreed to sell to ADM exclusively up to 40 million pounds of citric acid from its Groton plant for three years. The acquisition of Pfizer's assets in December 1990 ended Pfizer's 110-year history of leadership in the U.S. industry.

ADM's decision to enter citric acid production was almost inevitable once Cargill's move into the industry was known. The history of the two firms is replete with examples of duplication of product lines, though it was more common for Cargill to follow ADM's bold incursions into new fields than the reverse. Both companies had made entry into new biotechnology-based industrial products a high strategic priority beginning in the late 1980s. This strategic direction was partly a response to the sharp retardation of growth in their sales of high fructose corn syrup around 1986 and partly a response to new low cost starch fermentation techniques for making various organic chemicals traditionally synthesized chemically.

Pfizer's decision to exit the industry it had pioneered in America was doubtless spurred by the appearance of two formidable rivals with reputations for aggressive, growth-oriented tactics. Pfizer may have outfoxed another fox. The profit-and-loss statements of Pfizer's citric acid department examined by ADM before purchase may have shown a high rate of return despite its aging plants because prices had been propped up by a cartel in the late 1980's in which Pfizer had participated. Perhaps more important a factor in Pfizer's decision was the fact that ADM and Cargill were the two largest manufacturers of dextrose and other corn sweeteners. Had ADM built a new citric acid plant in 1990, Pfizer would have gone from being one of two manufacturers to one of four U.S. producers, a structure likely to have led to more price competition in citric acid. After entering citric acid manufacturing, Cargill and ADM would have become unwilling suppliers of dextrose to competing citric acid producers, and the number of alternative sources of dextrose was small. Therefore, Pfizer might have been squeezed by higher dextrose prices. Finally, Pfizer was probably aware that backward vertical integration of citric acid manufacturing brought down the cost by several cents per pound.[4] With access to high-yield microorganisms, Cargill would become the low cost producer in North America, allowing it to expand its market share at Pfizer's expense.[5] Faced with the likelihood of lower product prices and higher input prices after Cargill's and ADM's entry, Pfizer's decision to withdraw seems eminently sensible in retrospect. ADM's entry left Bayer's U.S. subsidiary alone exposed to this new competitive environment.

In the early 1990s, Cargill's share of the U.S. market grew quickly (Table 4.1). Cargill's new Iowa plant reportedly reached nearly full capacity within a year of its start up, so Cargill tripled its by 1993 (*Chemical Market Reporter* March 30, 1992). As a result of these investments, Cargill pulled ahead of Bayer/Miles in the U.S. market by 1995. However, ADM had meanwhile become the largest U.S. citric acid manufacturer by expanding its North Carolina plant from 100 million to 180 million pounds in late 1992. A few years later, ADM again expanded its North Carolina plant to 220 million pounds, thus solidifying its dominance in the U.S. market. By 1998, ADM accounted for about 40% of U.S. supply, and Cargill was not far behind it (Table 4.1). Bayer had been forced to cede its formidable position as dual leader in 1988, shrinking to a dismal 12% share of U.S. supply ten years later.

The Global Market

At the end of the 1980s, three of the world's top four manufacturers were European companies. In 1978, Miles Laboratories was acquired by the German pharmaceutical manufacturer, Bayer AG. Bayer later reorganized its U.S. operations by placing the responsibility for marketing citric acid under its fine-chemicals subsidiary Haarmann & Reimer. Although

4 On-site production of liquid dextrose permits pipeline delivery to the citric acid finishing plant. At a typical $0.15 to $0.25 per pound, rail delivery of dextrose was expensive, especially to Pfizer's two East Coast plants located hundreds of miles from the Corn Belt.

5 Jungbunzlauer in Europe also produced its feedstock at the same location it made citric acid, at least at its newer plants. ADM seems not to make dextrose at its North Carolina plant, but enjoys some economies in supplying its plant with its own dextrose. Bayer's six plants (one in the UK, two in the U.S., and three in Latin America) were not vertically integrated.

Bayer's headquarters are in Germany, it was in turn owned by a holding company organized under the laws of Switzerland. Similarly, Jungbunzlauer is an Austrian firm with its original headquarters in Vienna. Around 1994 Jungbunzlauer moved its operational center to Basel. Majority control of Jungbunzlauer is vested in the Swiss holding company Montana AG. Roche is a thoroughly Swiss company headquartered in Basel, Switzerland. Thus, at times it will be convenient to refer to the big three European manufacturers of citric acid as "the Swiss firms."

Bayer was the leader in the industry in 1989. In addition to the two plants it acquired in the United States in the late 1970s, Bayer bought a small UK citric acid plant in 1990. It had an annual capacity of 46 million pounds, but in a few years was de-bottlenecked to 72 million pounds. Bayer dominated citric acid production in Latin America with joint ventures in Mexico, Columbia, and Brazil (*Chemical Week,* August 1990). All told, Bayer controlled some 230 million pounds of citric acid plant capacity in 1989-1990, which was about 25% of global capacity at that time (Table 4.2). However, in the mid-1990s Bayer neglected to make many investments to expand its plants, so its share slipped.

By 1993 and for the rest of the 1990s, the leading producer in the world was Jungbunzlauer, with plants in Austria, Germany, and France. In 1991, it began to invest in a series of Asian joint ventures to make citric acid, the first in Sumatra, Indonesia. From one large plant in the early 1990s, the company operated four by 1993. Jungbunzlauer's newest plant in Alsace, France was the vertically integrated type, making both citric acid and its primary feedstock from corn in the same location. Its four production facilities gave Jungbunzlauer about 300 million pounds of capacity in 1993, which was almost one-third of estimated global consumption and about equal to Cargill and ADM's combined capacities. By the late 1990s, Jungbunzlauer's citric acid capacity had reached 500 million pounds.

Europe's third-largest manufacturer of citric acid in the early 1990s was the huge Swiss chemical maker Hoffmann-La Roche (Table 4.2). Roche operated a single large plant in Belgium that in 1990 had a capacity larger than Jungbunzlauer's. However, capacity at Roche's Belgian plant did not expand much in the early 1990s, while Jungbunzlauer was investing heavily in its new plant in Alsace as well as upgrading two

Table 4.2 Global Capacity Shares of Leading Citric Acid Suppliers, 1988-1998.

Sources of Supply	1988	1992	1996	1998
		Percent		
U.S. Manufacturers:	32	30	20	20
Bayer/Miles[a]	16	10	6	0

(*continued*)

Table 4.2 (*continued*)

Pfizer	16	0	0	0
Cargill	0	6	7	7
Archer Daniels Midland	0	10	7	8
Tate & Lyle/A.E. Staley	0	0	0	5
European Manufacturers:	40	38	43	38
Hoffmann-La Roche	9	11	6	6
Jungbunzlauer	15	17	19	17
Biocor	6	4	4	3
Bayer (outside U.S.)[b]	10	9	7	6
Palma Group	0	0	3	3
Asian Manufacturers[c]	22	25	33	39
Total[d]	100	100	100	100

Source: Connor (2001b: Tables 4.A.1 and 4.A.2)
[a] Bayer reorganized its U.S. operations during this period. Miles continued to manufacture citric acid, but overall marketing responsibility was granted to Bayer's fine-chemicals subsidiary Haarmann & Reimer.
[b] Includes three plants in Latin America and one UK plant sold to Tate & Lyle in 1998.
[c] Mostly Chinese production, but also one Israeli and two Indian plants.
[d] Excludes plants in the former Soviet Union.

older plants in Germany and Austria. As a result, Roche's share of citric acid capacity in Europe fell to about one-third of Jungbunzlauer's by 1996 and was about half of that of Bayer. Thus, while the three Swiss firms each had market shares of 10 to 15% in 1989, by 1996 Jungbunzlauer accounted for half of Europe's citric acid capacity and Bayer and Roche only about one-sixth each.[6]

Plants owned by the three Swiss and two smaller Italian firms gave Europe about 45% of global production capacity in the early 1990s, but Europe consumed less than 40% of the world's citric acid. Thus, unlike the North American companies, Europe's producers were export-oriented, shipping up to one-third of production to North America and other parts of the world. Roche and Jungbunzlauer were the two largest exporters to the United States in the late 1980s and early 1990s.

Although ranking third in the size of its citric acid industry, the fastest growth in production and consumption was occurring in Asia, particularly

6 Two relatively small Italian plants accounted for the rest of Europe's citric acid production. The older plant located near Pavia was operated by Biocor. This plant was sold by its UK owner in March 1990 and resold in late 1991 to Ferruzzi-Montedison, now called Eridania Beghin-Say. Italy's second citric acid plant began production in Calitri in early 1993.

in China. In 1989, Chinese citric acid capacity was about 150 million pounds, or about half as large as U.S. capacity. By 1995 Chinese production capacity had surpassed that of the United States, and by the year 2000 Chinese and European capacity was of equal size (roughly 1 billion pounds each). Production in China was scattered across 120 small-scale facilities owned by one sort of government entity or another. More than half of China's citric acid output was exported, at prices that were substantially below those in Europe or North America. The low prices reflected both low quality and low production costs. It appears that the Chinese government provided export subsidies to citric acid exporters at a rate of about 5 to 10 cents per pound until about 1994. With annual growth exceeding 20% per year, by the early 1990s China was a looming threat to existing Western manufacturers, especially European exporters.

Members of the Cartel

Four companies joined the price-fixing conspiracy that their managers came to call the G-4 or "the club." As will be related in the next chapter, the G-4 was formed one day in March 1991 and fell apart sometime in early 1995. From November 1992 until April 1994 a fifth firm, Cerestar Bioproducts NV, was a member of the cartel. Cerestar is a subsidiary of Eridania Beghin-Say, a very large French-Italian agribusiness firm. While Cerestar remained in the cartel, it called itself the G-5.

Normally the structure of the market (many sellers, easy entry, or heterogeneous products) or fear of contravening the antitrust laws prevents the formation of a cartel. However, acting in concert, the G-4 was able to perform a feat that most business people can only dream about – moving the global market for its product in a direction that generated profits several times higher than the level in the pre-cartel period. This magical intervention into the normally all-powerful market mechanism by the G-4 was akin to a ship sailing against the wind.

Archer Daniels Midland Co. (ADM) was the G-4's prime mover. The trip made by the company's top two citric acid executives, Wilson and Cox, in January 1991 was the initial contact among the four. Doubtless, ADM's peace offering to the three Swiss firms was well received. Wilson probably explained in subtle ways ADM's corporate philosophy: friendly relations among competitors to achieve the joint exploitation of their customers.

It is useful to digress at this point to provide quick portraits of ADM, Cargill, and the three Swiss companies before moving on to the conspiracy story. These profiles will sketch each of the companies' strategies and financial conditions when the cartel was formed and active. They will focus on organizational or management characteristics that may have made the companies susceptible to opting for an overt conspiracy.

Archer Daniels Midland Co.

ADM is the largest publicly traded agribusiness company in the United States and second largest in the world.[7] For three decades beginning in 1965, when Dwayne O. Andreas was appointed its CEO, ADM had enjoyed a long period of rapid growth, diversification, and profitability. Andreas was a colorful, outspoken agribusiness leader known for his bold strategic moves into new ventures, big international deals, and carefully cultivated political friendships. ADM was Andreas' creature. Its management structure had few layers, investment decisions were quick, and it benefited from numerous government contracts and subsidies (Figure 4.2). Until the lysine price-fixing scandal broke in 1995, ADM was one of the most admired American manufacturers.

In fiscal year 1995, ADM reported consolidated net sales of $12.7 billion (ADM**).** However, gross sales, which include the total sales of merchandised grain and oilseeds, and the sales of unconsolidated joint ventures, were approximately $70 billion. During the decade up to 1995 ADM's net sales increased by 10.1% per year. ADM's earnings per dollar of sales were about double those earned by most agribusiness firms, but they were quite variable. In the late 1980s net earnings had risen by 20% per year, but from 1990 to 1994 ADM's growth in net earnings stalled.

ADM has four major product divisions: oilseed products, corn starch products, bioproducts, and other grains; in 1995 the four divisions contributed about 60, 20, 5, and 15% of net sales, respectively. The cornstarch division produces corn sweeteners, cornstarch, alcohols, malt, and a host of biotechnology food ingredients (monosodium glutamate, citric acid, ascorbic acid, biotin, lactic acid, sorbitol, and xanthan gum). Four amino acids (lysine, methionine, trytophan, and threonine) were made by the Bioproducts Division and sold to manufacturers of animal feeds. Within the corn products division, corn sweeteners and ethanol had become mature products with slow growth and narrowing margins; however, the other bioproducts from corn generate much higher margins and represented ADM's hope for the future.

For a company of its size and diversity, ADM was managed by a remarkably small number of managers. Dwayne Andreas and three or four other top managers made all major decisions, largely unfettered by ADM's

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7 Agribusinesses" are companies that primarily trade in or process agricultural commodities, buying from and selling to agricultural producers or other food processors.

subservient board of directors. Until late 1996, the highly paid Board contained a large majority of current and former company officers, relatives of Andreas, long standing close friends of Andreas, or officers of companies that supply goods and services to ADM (agricultural cooperatives or legal services). Strictly speaking, at most two of the Board's 17 members were independent of ADM or Andreas.

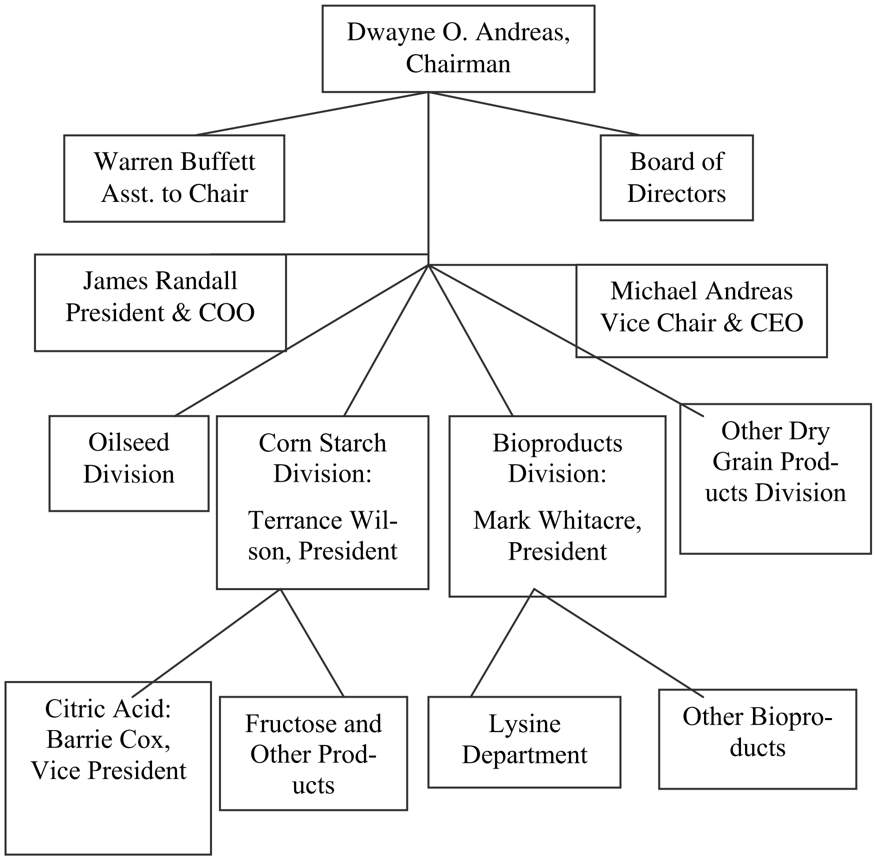

Figure 4.2 ADM's Management Structure, 1991-1995.

Note: May not correspond to the company's formal reporting structure, but reflects the actual decision-making structure of the company.

By 1990, Dwayne's son Michael had become the anointed successor to his aging father. Michael had effectively become the company's Chief Executive Officer, while Dwayne concentrated most of his time on broad strategic decisions and external relations. The company was famously unconcerned about public and investor relations. Members of the press or stock analysts almost never had open contact with ADM officers except rarely with D. Andreas himself. ADM's flexible management style was so admired by multi-billionaire investor Warren Buffett that he sent his son Howard to spend several years as a special assistant to Dwayne Andreas in the early 1990s.

An October 1995 profile of Dwayne Andreas and ADM by the *Wall Street Journal* emphasized the CEO's extraordinary grip on the company. Although he personally owned less than 5% of ADM's stock

> ". . . Andreas has gained near total control with the help of family members, loyal executives and directors whose combined stakes is nearly 15%. He collaborates with his biggest competitors, spends prodigiously to influence the media and public opinion, and spreads large sums among politicians of all stripes." (p.A1).

Unusual among agribusiness companies, ADM has many collaborative arrangements with parties that normally would be considered rivals. Andreas often said, "Keep your friends close and your enemies closer." So, in 1992, ADM built a 3.5-mile pipeline from its Decatur plant to its rival A.E. Staley's plant just before Staley was threatened by a labor strike. ADM owns significant shares in Staley's parent, Tate & Lyle, and has a fructose joint venture with Staley in Mexico.

Andreas cultivated the image of an international statesman with strong concerns about environmental matters, world hunger, and national food security. His official biography gives him undue credit as one of the major forces behind the U.S. Government's PL 480 Program that ships excess farm commodities to poor countries (Kahn). He was often identified as the U.S. capitalist with the closest relationship with Kremlin and other Eastern Bloc leaders going back to Joseph Stalin in the 1950s. Andreas built a legendary network of powerful business and government contacts. He was close friends with and contributor to a wide array of farm-state politicians and spent a good deal of his time sponsoring political fund-raising events.[8] ADM has benefited greatly from the U.S. sugar program

[8] Andreas made deft use of his wealth. "Andreas, his family, and ADM are by far the largest political contributors in the country" (Hollis). These contributions resulted in adverse publicity for Andreas at least four times. He wrote a $25,000 check that was given to B.L. Barker, one of the convicted "Watergate Burglars," and a bundle of $100,000 in cash given by Andreas was found in Richard Nixon's White House safe; Andreas avoided testifying about these gifts. Later, Andreas was prosecuted but not convicted for an illegal $100,000 corporate contribution to Hubert Humphrey. In 1993, Andreas and his wife were fined $8,000 by the Federal Election Commission for making excess political contributions.

and from federal ethanol subsidies and usage requirements (Bovard 1995). Lobbying by ADM through its trade associations for these and other government favors is intense and well documented.

There are several ADM management practices that bear the Andreas stamp and that could have made ADM prone to price fixing. ADM made quick and aggressive investment decisions. To enter the citric acid business, ADM paid top dollar for two aging Pfizer plants primarily to obtain the production technology. In both lysine and citric acid, very large capital expenditures were incurred to expand plants to the largest feasible scales. When production problems occurred with lysine, ADM hired away engineers from their primary competitor, Ajinomoto. Former ADM vice president Mark Whitacre claimed that "stealing technology" was common practice at ADM. The technological leader in the lysine industry, Ajinomoto, successfully sued ADM in late 1996 for patent infringement on production methods for lysine and threonine.

Whitacre was of the opinion that a culture that fostered or permitted price fixing permeated ADM. Dwayne Andreas dismissed the idea of "free markets," an idea he considers to be a figment of politicians' imaginations (Bovard 1995). That is, Andreas tended to view agricultural markets, both in the U.S. and trade among nations, as the products of personal negotiation between powerful leaders. Markets, he testified, are essentially creatures of government regulation and power. ADM's participation in five cartels tends to support some of Whitacre's charges.

Among people familiar with agribusiness, ADM ". . . long had a reputation for business practices that were close to the edge" (Nicol and Ferguson 1999:50). In 1978, ADM pleaded "no contest" to charges that it had colluded to fix prices on food sold by USDA for international relief programs. In 1992 and 1994, the company paid $2 million to settle civil antitrust suits alleging that ADM had conspired to fix prices on carbon dioxide, a by-product of its corn fermentation processes. As is typical in such civil settlements, the defendants do not admit their guilt in a formal legal sense. Yet, the impression is conveyed that the defendant judged that there was a good chance that in court the preponderance of the evidence might have turned against them. These precursors merely hint at the massive price-fixing activities pursued by ADM's top management from 1991 to 1995.

Cargill Corporation

Cargill is the world's largest agribusiness company, but because it is privately owned by a couple hundred members of the founding families, many details of the company's operations, organization, and finances remain hidden from public view. In 1986, Cargill had sales of $32 billion, which were four times the size of ADM's consolidated sales in that year. By 1999, Cargill's total sales were $46 billion, making it the largest privately owned industrial company in the United States (Connor 2000: Appendix F).

In terms of sales growth, the 1970s were a high point for Cargill. The combination of volume growth, acquisitions, and commodity price inflation raised the company's sales by 1,200% from 1971 to 1981. However, after completing a major purchase in the meatpacking industry in 1987, a five-year period of financial stress plagued Cargill. One major reason was the sharp slowdown in the growth of its corn wet milling business. Following ADM's lead, Cargill had invested heavily in a couple of huge corn refineries that made starch, oil, sweeteners, and other products. Growth of the most profitable product line, high fructose corn syrup (HFCS), hit a wall around 1987 as the opportunities for further substitution for sucrose dried up.

Like ADM, Cargill began to explore opportunities to utilize its large supplies of cheap corn sweeteners to make further-processed, high-value-added agrichemicals by means of advanced fermentation technologies. One of its first biotechnology ventures was citric acid. It was around 1987 that Cargill decided to build finishing capacity to make citric acid from dextrose produced at its newest corn-refining plant in Nebraska. Production of citric acid began in 1991, and after several expansions of capacity in the early 1990s, Cargill became a strong second in the U.S. industry behind arch-rival ADM. Cargill's April 1998 announcement of a new Iowa lysine plant was almost immediately countered by an ADM press release about construction of its *second* lysine facility. A few months later Cargill held a groundbreaking ceremony for its new lysine plant, with a capacity quite a bit bigger than the original announcement. Cargill had formed a partnership with Degussa, the world's leading manufacturer of amino acids, and the company that ADM had prevented from entering the U.S. industry by its preemptive strike in 1989. The Degussa partnership is only one of several that Cargill has formed in order to move decisively into the high-margin bioproducts area.

Bayer AG

Bayer has title to being the world's largest chemical company. In the late 1990s, Bayer's sales were only slightly below those of BASF, but in terms of numbers of employees or profit it was well ahead of BASF. In the late 1980s and early 1990s, it was Hoechst that had the number-one spot, so it is best to think of the big three German chemical firms as jockeying for primacy in the 1990s. All three firms were carved out of the infamous 1925-1947 I.G. Farben chemical monopoly that is best remembered for its collaboration with the Nazi regime and the conviction of its directors for crimes against humanity at the Nuremberg trials (Connor 1999: Appendix F).

In 1954, Bayer began investing in the United States. One of its largest foreign investments was the acquisition of Indiana-based Miles Laboratories in 1978. Among Miles' assets were two citric acid plants that gave Bayer half of the U.S. plant capacity for citric acid and about 40% of market sales. Testimony at a 1998 antitrust trial revealed that during the 1980s, Miles conspired to fix the U.S. prices of bulk citric acid with the only other U.S. manufacturer, Pfizer Corp. of New York City.[9]

Bayer enjoyed decades of nearly uninterrupted growth until about 1988, but then hit a plateau of financial performance that lasted several years. Bayer responded to this crisis by severe cost cutting (including large layoffs of employees in its European plants), an increase in foreign direct investment in fast growing markets, and restructuring of assets. It became the sole producer of citric acid in Latin America, with three or four small plants there. In 1994 Bayer's considerable U.S. assets were grouped under a new U.S. subsidiary named Bayer Corporation.

Hoffmann-La Roche AG

Roche Holdings, Ltd., a Swiss holding company, is often better known by the name of its principal operating company, F. Hoffmann-La Roche AG. Headquartered in Basel, Roche has been focused on nutritional and pharmaceutical products from its beginnings in the late 19th century. During the 1920s and 1930s, Roche moved away from its early reliance on medicinal extraction and increasingly applied its extensive R&D resources to chemical synthesis. Among its greatest early successes were the discoveries of synthetic processes for making vitamins C, A, and E. By the early 1970s, Roche controlled 50 to 70% of the world market for bulk vitamins. In the 1960s Roche profited greatly by becoming the first firm to

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[9] The conspiracy was revealed by a former Pfizer employee in 1996 to the FBI. Bayer and Pfizer could not be prosecuted for price-fixing because of the statute of limitations.

market tranquillizers. However, failure to find profitable replacements for its tranquillizers, the patents on which expired in 1985, placed Roche under some profit pressures in the late 1980s.

In the 1990s Roche responded to its reduced prospects for profitability by redirecting its capital investments toward biotechnology ventures. In 1997, Roche had global sales of $12.9 billion and employed 51,600 persons. Almost two-thirds of its sales consist of pharmaceuticals, but it was also a world leader in flavors, fragrances, vitamins, carotenoids, and genetic-engineering products. In that year, Roche's net income was an enviable $2.9 billion or 22.8% of sales. Its major U.S. subsidiary, Hoffmann-La Roche Inc., had sales of almost $1 billion.

Jungbunzlauer AG

Jungbunzlauer International AG was by far the smallest member of the citric acid conspiracy. In its 1991 annual report, the company stated that it had 243 employees generating a mere $96 million in sales. But because it was highly specialized in making citric acid, it had one of the highest market shares in the citric acid cartel.

This company traces its roots to an alcohol distillery built in Jungbunzlau, Bohemia in 1895. It moved its registered office from Prague to Vienna in 1902. Jungbunzlauer diversified into the production of citric acid in 1962 from its single plant in Pernhofen, Austria, but soon became heavily indebted. A capital infusion from the Swiss holding company, Montana AG, took place in 1967. This holding company obtained a majority interest in Jungbunzlauer by the early 1990s. Sometime around 1994, Jungbunzlauer's headquarters was moved to Basel, Switzerland.

A stock prospectus issued by Jungbunzlauer in 1985 purported to show that the company was fairly profitable, making before-tax profits of 10% of sales in the preceding years. However, from 1986 to 1991, Jungbunzlauer's profits and its stock performance were quite unstable. Its average of profitability was moving down sharply. Despite its perilous financial condition, Jungbunzlauer made a large investment in a second citric acid plant located in Ladenberg, Germany. That purchase in 1989 made the company the world's third largest manufacturer of citric acid. Moreover, in 1990 Jungbunzlauer began to build a very large citric acid facility on the Rhine River in Alsace, France. The company also invested heavily in upgrading and expanding its Austrian and German plants. These projects raised Jungbunzlauer's production capacity to 310 million pounds by

1993, about 20% of the world's total, vaulting Jungbunzlauer past Bayer into first place (Connor 2001: Table 4.A.2).

Jungbunzlauer looks like a small player hell bent on aggressive growth to become and stay the biggest in citric acid. Its 1991 financial report stated that its main products were citric acid, gluconates, and xanthan gum – all made by fermentation. By 1997, Jungbunzlauer reported having 428 employees in its Austrian and German plants with total sales of $300 million – triple its 1991 sales.

International Trade Patterns

International trade provides information that helps in understanding the operation and economic impacts of the global dimensions of the citric acid conspiracy. Citric acid is a storable commodity and in its dry forms (citric salts) sells at a price high enough to justify being shipped internationally. As soon as the price differences between two continents widen to at least five or ten cents per pound, there is sufficient profit incentive for manufacturers or wholesalers to sell abroad, an activity dubbed "geographic arbitrage" by economists.

When a group of sellers tries to form a purely national price-fixing conspiracy, unless trade barriers exist, the sellers are limited in their ability to raise prices because at some price level imports will flood the national market. When a cartel is formed that aims at controlling intercontinental prices, it must set those prices at levels that will not permit geographic arbitrageurs to undermine the desired geographic price levels. Because currency exchange rates are uncontrollable and somewhat unpredictable, global price fixing is more complicated than a domestic conspiracy. The daily fluctuations in exchange rates among most major currencies compel would-be price fixers to alter their local prices at frequent intervals. The lysine cartel began by setting target prices only using the U.S. dollar, but with experience eventually set prices in a dozen national currencies. Price quotes were usually kept constant between meetings. As will be seen, the managers of the citric acid and lysine cartels believe that formal quarterly meetings were necessary, supplemented by frequent telephone communication between those meetings.

From 1981 to 1989, the United States imported between 20 million and 65 million pounds of citric acid, with the amount increasing nearly every year (Connor 1998: Figure 2). The imports were responding to relatively high U.S. domestic prices. Most U.S. imports originated from Jungbunzlauer's German plant and Roche's Belgian plant. Most U.S. exports went to Canada and were by comparison quite modest, in the 10 to 20 million pound range. Thus, the U.S. trade balance became increasingly negative from 1981 to 1988.

However, the trade balance made a remarkable turn-around in 1989 and 1990. In response to the impending opening of Cargill's new citric acid plant in Iowa, U.S. prices began to fall in late 1989. List prices had been in the $0.81 to $0.84 per pound range in 1988 and early 1989 (Connor 1998: Appendix Table 1). However, in anticipation of the large additional quantities that Cargill would bring to the market in the spring of 1990, list contract prices suddenly fell to $0.75 per pound in late 1989 and continued to be cut quarterly during 1990. Prices fell precipitously throughout 1990. Transactions prices for citric acid fell from $0.81 per pound in late 1989 to as low as $0.62 at the end of 1990. Cargill began sales from its new plant in June 1990 and probably cut prices to win over new customers. Moreover, ADM's takeover of Pfizer's plants in late 1990 and its announced intention to expand capacity further depressed U.S. prices. Transaction prices remained low ($0.60 - $0.65 per pound) through June 1991.

As a result of these lower prices, U.S. imports fell by 10 million pounds in 1990 compared with 1989, and exports rose by 25 million pounds. In 1990, U.S. citric acid trade was virtually in balance for the first time in more than a decade. Moreover, exports climbed again in 1991 by nearly 30 million pounds, aided by the expansions of both ADM's and Cargill's plants and prompted by excess production capacity. In 1991, the U.S. experienced its first trade surplus in citric acid for more than a decade.

What was good news for the United States' balance of trade must have been viewed with dismay by the Swiss firms. As American exports began to flow to destinations other than Canada, they would have displaced European exports to those countries. Continuing export expansion by Chinese producers merely added to their woes. It is likely that Jungbunzlauer's and Roche's plants in Europe experienced notable declines in capacity utilization, a factor that typically causes production costs to increase. Moreover, these firms probably were being forced to cut prices on the one-fourth to one-third of their production that was historically exported. This was particularly bad news for Jungbunzlauer, which depended on citric acid sales to a greater extent than Roche or Bayer and which was in the midst of a large expansion program. It is also likely that Bayer's Latin American operations were facing a similar squeeze on margins.

Although the newly competitive U.S. industry may have been a temporary phenomenon occasioned by Cargill's large-scale entry, the Swiss firms were very likely in a precarious financial position with respect to their citric acid businesses in the spring of 1991. ADM's peace offering could not have come at a better time.

Costs of Production

Specific information on costs of producing and marketing citric acid by various major sellers is not revealed in the record, but certain inferences can be made from other information. Some idea of cost of production is useful in assessing the strategic behavior of the leading firms and in measuring the economic performance of firms and markets (see Box).

Based upon the trade patterns in the 1980s, it seems quite likely that the costs of producing citric acid in Europe were lower than those in North America. In late 1990 and early 1991, when Cargill's new integrated plant had been up and running for some time, trade patterns reversed in such a way as to suggest that U.S. costs had achieved parity with European costs. However, the low U.S. selling prices may have been a transitory phenomenon, suggesting that U.S. producers may have only been covering their short-run costs at that time. Moreover, one cannot discount the possibility that Cargill might have been willing to sell at a price below long run average total costs in its first year to quickly grab a market share sufficient to achieve the low costs associated with higher levels of plant capacity utilization.

A couple of articles in the trade press provide hints of industry views on production costs (*Chemical Marketing Reporter* June 3, 1991 and July 22, 1991). In late 1990, some buyers were reporting heavily discounted transactions as low as $0.55 per pound, and this price was said to be only slightly above "production costs," which is probably the average total costs of manufacturing alone. When prices were in the $0.60 to $0.65 range, unnamed sources indicated that sales were unprofitable for all U.S. manufacturers, Cargill included. Thus, average total costs in the early 1990s may have been as high as $0.70 to $0.75. In the late 1990s U.S. manufacturers were profitable at prices of $0.61 to 0.69 (USITC 2002).

In 1988 manufacturing costs at Bayer's two U.S. plants were $0.42 to $0.48 per pound (Anon. 2001). Adding a generous allowance for central office expenses, selling costs, and a normal return on investment, Bayer's total average costs were $0.52 to $0.58. At an average selling price of $0.74 per pound, Bayer's gross profit margin was 25% of sales. During the collusive years 1994-1995 costs rose by 20 to 30%.

Costs of production abroad can provide some information about competitive prices in Europe or America. In December 1998, Mitsubishi

Costs of Production

Economic theory places great weight on costs of production as a determinant of a firm's decision to find its profit-maximizing level of production or for a firm with market power to set its optimal selling price. It is important to distinguish between long-run and short-run costs and between marginal and average costs.

The *short run* is a period of production too short for a new capital investment to make a difference in output. In the context of manufacturing the *long run* is the length of time necessary to plan, design, build, equip and debug a new plant – about two to three years for the citric acid industry. In the short run a company can ignore capital costs when setting prices or output levels (possibly incurring losses in net revenues), but in the long run all costs must be covered.

Firms consider only their marginal costs when optimizing production. However, marginal costs, the incremental costs associated with a one-unit increase in output, are difficult to measure precisely with accounting data. In practical analyses of company or industry performance, accounting data must be utilized. Accounting total costs consist of *variable* costs (costs that change with levels of output) and *fixed* costs. Variable costs include the labor, materials, and energy needed for manufacturing; costs of packaging, delivery, and storage; and selling costs. Fixed costs include such items as capital depreciation, insurance, interest payments on long-term debt, and a reasonable return to the owners of the company's equity. Roughly speaking, in the short run a firm must receive a price sufficient to cover its average variable costs. In the long run, price must cover average total costs.

A very common finding in studies of manufacturing industries is that average variable costs of small plants are higher than medium-size plants. Similarly, new plants operating at low utilization levels have higher costs than plants operating close to optimal levels with experienced personnel. However, the differences in average variable costs of mature medium-size plants and larger plants tend to be negligible. This is important because it implies that over this medium-large size range, long run marginal cost will be equal to average variable costs.

Corporation of Japan announced that it would be building a new plant to make citric acid in Thailand. The plant would use inexpensive local supplies of tapioca meal as the principal feedstock for fermentation. What was unusual about this announcement was Mitsubishi's revealing the fact that its marketing plan was based on a cost of production, insurance, and freight (the CIF price) of citric acid to Europe or the United States would be $0.58 per pound.[10] Allowing some additional costs for sales brokers and domestic transportation charges suggests an average U.S. delivered price of about $0.65 per pound, well within the range of average total costs from other sources.

One final indicator of costs in the U.S. is what happened to prices after the citric acid cartel ceased operating in early 1995. During 1996 and early 1997, citric acid transactions prices hovered in the narrow range of $0.69 to $0.73 (Connor 1998: Appendix Table 1). On the assumption that this was a relatively competitive period, this price may approximate average total economic costs. Thus, the evidence available suggests that in the early 1990s average total costs were very likely between $0.65 and $0.75 per pound.

Selling Practices

Most citric acid was sold under annual supply contracts directly by the manufacturers or their agents to food and detergent manufacturers. The contracts would specify the product form (food grade or industrial grade, liquid or anhydrous), the quantity to be purchased during the upcoming quarter or calendar year, method of delivery, and payment terms. Most large buyers negotiated their contracts in the final quarter of the year. The contract would specify the price to be paid, but sellers had the option of announcing price changes "effective immediately" or at short notice at any time during the life of the contract. However, buyers usually had the option of buying extra product (often a month's supply) at the old price if a price increase was made; this is referred to as a "price-protection clause."

Citric acid manufacturers sent notices to the press and their customers of changes in their "list" price. These were starting points for price negotiations that took place in secret between manufacturers' sales representatives and purchasing managers. The most common list price referred to large lots (full truck loads or tanker-car loads) of anhydrous USP food grade citric acid, delivered to customers near the plant.[11] Standard premiums applied to partial truckloads (four to eight cents per pound) and to deliveries west of Denver (three cents). Once the terms of the contract were

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[10] That is, the cost of production in Thailand would seem to be $0.50 per pound, and might fall as the small plant (15 million pounds per year) expanded.

[11] USP is an abbreviation for United States Pharmacopeia, one of the standard references for the technical standards required for a food or pharmaceutical product to be sold as suitable for human use.

set and the types of premiums were known, the only item to be negotiated was the price. The largest and oldest customers often expected discounts in the form of rebates when they signed contracts. Contract customers could request additional quantities during the year, but the price of these supplementary purchases would be renegotiated separately.

In addition to contract sales, manufacturers sold product on a "spot" basis. Spot sales were for immediate delivery and frequently for partial truckloads. Like groceries purchased at a convenience store, such fill-in shopping behavior usually meant paying a premium over contract prices. In early 1990, for example, contract prices were 3% lower than list while spot prices were slightly higher than list. In 1995, perhaps a more typical year, contract prices averaged 10% below list and spot prices 8% below.

There are no organized markets for citric acid with attendant public reporting of transaction prices. Although list prices were faithfully reported by the trade press, fitful articles on transaction prices were normally untrustworthy. Methods of exchange such as those just described for citric acid tilt price information in favor of the few sellers as opposed to the many buyers. The hidden nature of the negotiations makes it difficult for buyers to perform price checks and makes it easy for sellers to bluff about what alternative buyers are paying. Such methods of exchange are highly compatible with and may facilitate price fixing.