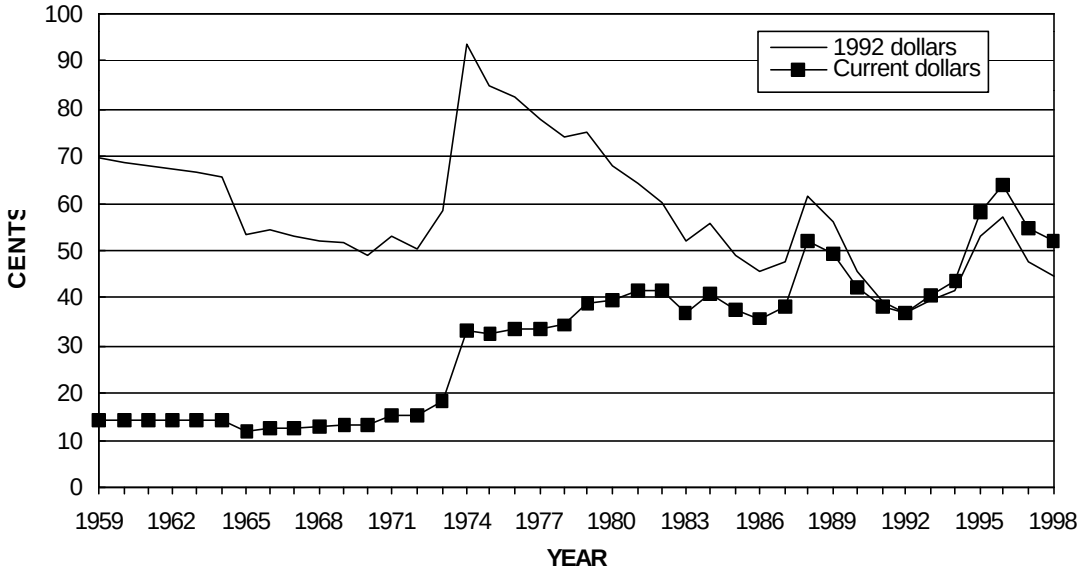
Silicon

by Thomas S. Jones

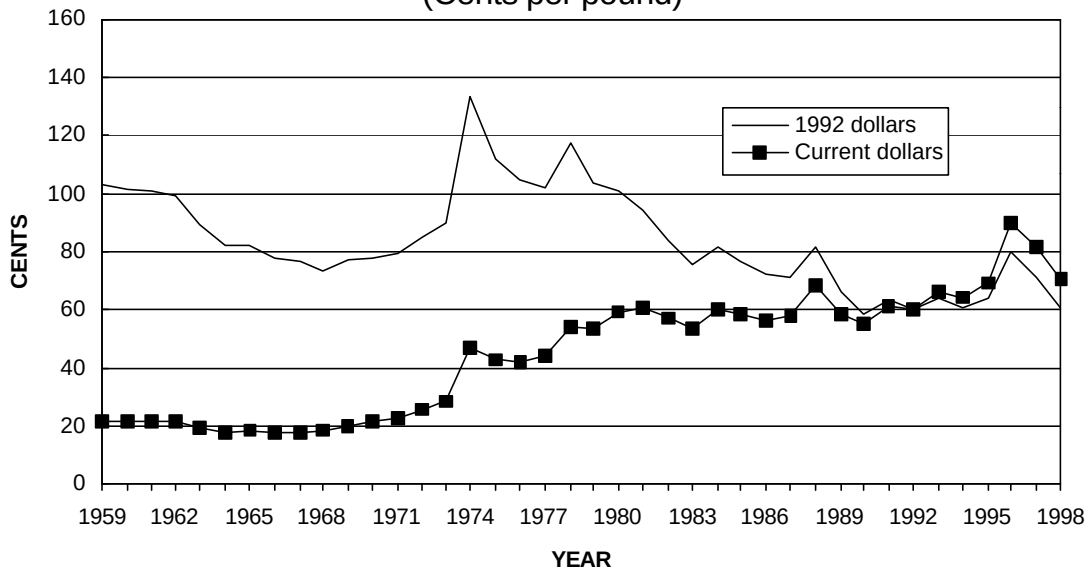
Annual Average 50% Ferrosilicon Price

(Cents per pound contained silicon)



Annual Average Silicon Metal Price

(Cents per pound)



Significant events affecting silicon prices since 1958

1974	Lifting of price controls
1980's	Imports of silicon materials capture a growing share of U.S. market
1988	Strength in steel production
1991	Antidumping duties assessed on U.S. silicon metal imports
1993-94	Antidumping duties assessed on U.S. ferrosilicon imports
1996	Period of strong demand

Silicon is a light chemical element with metallic and nonmetallic characteristics. It is second in importance to manganese in overall steelmaking. In the form of ferrosilicon, silicon is used for deoxidizing and as a strengthening alloy in the production of iron and steel. Silicon metal is used primarily in the aluminum and chemical industries.

Principal elements in the cost of silicon and ferrosilicon production are the delivered costs of the ore (quartz or quartzite) and the costs of energy, reductant coke or low ash coal, iron in the form of steel scrap (if required), and labor. These costs, and particularly that of energy, have increased rapidly since 1970. In addition, new capital costs for pollution control equipment have been incurred. Bulk ferroalloys produced in submerged-arc furnaces are extremely power intensive, especially silicon metal and silicon-containing alloys, which can require up to 14,000 kilowatt-hours of electric energy per metric ton of silicon contained in the final product (Dosaj, 1997). Energy is the largest cost component in the production of silicon metal and silicon-containing alloys and can account for one-fifth or more of total costs (de Linde, 1995).

Specifications for silicon metal used by the primary aluminum and chemical industries generally are more stringent than those for metal used by the secondary aluminum industry. Price trends for the small quantities of high-purity, high-value silicon produced for electronic uses are not addressed in this chapter. Data for U.S. exports in 1997 indicate that the cost of silicon for manufacture into the chips upon which modern computer technology is based averages as much as 30 times that for metallurgical and chemical uses.

Based on usage and nominal silicon content, the main varieties of silicon ferroalloys have been 50% ferrosilicon, 75% ferrosilicon, and specialty ferrosilicons. The price trends discussed here are for 50% ferrosilicon, simply referred to as "ferrosilicon" in the following text. Trends for 75% ferrosilicon have been much the same since at least 1980. Of the specialty ferrosilicons, the most important is perhaps magnesium ferrosilicon. For that ferroalloy, Metals Week has not listed a price since 1978, but American Metal Market has published prices with an effective date as recent as July 21, 1995.

The customary basis for quoting prices for silicon materials is in terms of silicon content, so that for the United States the price unit has been cents per pound of contained silicon. On this basis, the silicon units in silicon metal, because of their higher energy content, are more costly than those in ferrosilicon, for which no allowance is made for iron content. From 1959 through 1998, the ratio for the price of silicon contained in metal to the price of silicon contained in ferrosilicon fluctuated considerably, averaging about 1.45 overall.

E&MJ Metal and Minerals Markets and its successors (Metals Week in 1967 and Platt's Metals Week in 1993) are believed to have been the source of most, if not all, of the price data tabulated. In these publications, updating of U.S. producer prices ended about 1991, and their listing was formally suspended in 1996. The price basis throughout has been bulk lots, free on board (f.o.b.) shipping point for producers and f.o.b. warehouse, duty-paid, for dealer quotes for imports. In recent years, the prices in Platt's Metals Week have been exclusive quotations based on canvassing. The price tabulated for silicon metal generally has been for metal with a typical iron content of 1%.

Demand for metallurgical-grade silicon alloys and metal is little determined in the short term by their prices but rather by the level of activity in the steel, ferrous foundry, aluminum, and chemical industries. As a result, prices tend to vary widely with changes in demand and supply. The price versus time curves for silicon and ferrosilicon are quite similar for the period from 1959 through 1998. For both materials, prices rose steeply in 1974 and peaked markedly in 1988 and 1996. Since 1974, prices have grown at a compound annual rate of about 2.2%. This rate is much lower than the general rate of inflation as given by the Consumer Price Index, which advanced during the 1970's at about 8.6% per year and since the early 1980's at about 3.6% per year.

From 1959 through 1969, the price of silicon alloys and metallurgical-grade metal remained reasonably stable. During this period, the domestic producer price fluctuated between 12 and 14.5 cents per pound for ferrosilicon and between 18.1 and 21.9 cents per pound for metal.

Prices began to rise in the early 1970's owing to higher costs of scrap iron, metallurgical-grade coal, and electric power and the cost of newly installed pollution control devices to comply with governmental standards, which became effective in 1975 (Murphy and Brown, 1985). Prices for

silicon materials increased sharply after Government controls imposed on ferroalloy prices were lifted in early 1974. Prices increased to 32.5 cents per pound for domestically produced ferrosilicon and to 47 cents per pound for metallurgical-grade metal; these prices were more than double those of 1970. Prices rose steadily from 1977 through 1981 in response to increased demand, rising inflation, and higher energy costs.

Prices peaked in 1988 owing to stronger demands from the aluminum, iron and steel, and silicon-base chemical industries, and by the end of the year, domestic producers were operating at close to capacity (Gambogi, 1990). Increased demand and rising prices persuaded some producers throughout the world to restart existing facilities and to make plans for future expansion. By yearend 1990, however, the then-record high prices of 1988 had declined significantly. The sudden decline in prices was caused mainly by oversupply of material resulting from the reactivation of idle capacity, development of new capacity in South America, and escalation of low-cost imports from China, South America, and the then-U.S.S.R. Consequently, in response to a continuing soft world market, several domestic producers scheduled production cutbacks.

Subsequently a number of domestic producers of silicon materials were alleged to have engaged in price fixing during 1989 through 1991. As a result of the investigation of these charges by the U.S. Department of Justice, two firms pled guilty and received fines in 1995-96 for price fixing of ferrosilicon (Jones, 1998). In 1997, a third firm was found guilty of price fixing of ferrosilicon (Megregian, Babbitz, and Kress, 1998).

In the 1990's, prices for silicon materials were influenced by the imposition of protective tariffs. Starting in 1980, imports of silicon metal and silicon ferroalloys captured an increasingly large share of the U.S. market, with a resultant decline in use of U.S. productive capacity. By the late 1980's, domestic producers had petitioned the U.S. Department of Commerce and the U.S. International Trade Commission for relief against alleged dumping of silicon metal imports from Argentina, Brazil, and China. In mid-1991, the two agencies concluded their investigations and made affirmative determinations that resulted in imposition of antidumping duties. For ferrosilicon, a similar sequence of events resulted in the imposition of antidumping duties in 1993-94 for a number of foreign sources. In subsequent years, at least some of these duties have been the subject of annual administrative reviews and court challenges that led, in certain cases, to revisions of the duties.

The 1996 price peaks for ferrosilicon and silicon metal, which are the highest on record, appeared to have been related to supply-demand conditions. These peaks, as well as those in 1988, roughly coincided with upturns in world steel production indicating a period of strong demand. Prices subsequently decreased in 1998, at least partly as a result of the deteriorating economic conditions in Asia and Russia.

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Annual Average 50% Ferrosilicon Price

(Cents per pound contained silicon[1])

Year	Price	Year	Price	Year	Price	Year	Price
1959	14.5	1969	13.5	1979	38.8	1989	49.6
1960	14.5	1970	13.6	1980	39.8	1990	42.4
1961	14.5	1971	15.3	1981	41.5	1991	38.3
1962	14.5	1972	15.0	1982	41.4	1992	36.9
1963	14.5	1973	18.5	1983	37.1	1993	40.8
1964	14.5	1974	33.0	1984	41.2	1994	43.9
1965	12.0	1975	32.5	1985	37.5	1995	57.9
1966	12.6	1976	33.5	1986	35.6	1996	64.0
1967	12.6	1977	33.5	1987	38.5	1997	54.8
1968	13.0	1978	34.5	1988	52.1	1998	52.1

Annual Average Silicon Metal Price

(Cents per pound[1])

Year	Price	Year	Price	Year	Price	Year	Price
1959	21.4	1969	20.1	1979	53.7	1989	58.8
1960	21.4	1970	21.5	1980	59.2	1990	54.8
1961	21.4	1971	22.9	1981	61.0	1991	61.5
1962	21.4	1972	25.4	1982	57.4	1992	60.0
1963	19.5	1973	28.4	1983	53.8	1993	66.4
1964	18.2	1974	47.0	1984	60.4	1994	64.1
1965	18.5	1975	43.0	1985	58.8	1995	69.5
1966	18.0	1976	42.5	1986	56.3	1996	89.7
1967	18.1	1977	44.0	1987	58.1	1997	81.4
1968	18.3	1978	54.5	1988	68.7	1998	70.5

[1] To convert to cents per kilogram, multiply by 2.20462.

Note:
1959-66, U.S. producer price, *in* E&MJ Metal and Mineral Markets.
1967-79, U.S. producer price, *in* Metals Week.
1980-93, U.S. dealer import price, *in* Metals Week.
1993-98, U.S. dealer import price, *in* Platt's Metals Week.