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Selected Raw Material Requirements for Japan's Specialty Steel Industry

By E. Chin, John C. Wu, L. Nahai, Gordon L. Kinney, and Charles L. Kimbell

UNITED STATES DEPARTMENT OF THE INTERIOR

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UNITED STATES DEPARTMENT OF THE INTERIOR
James G. Watt, Secretary

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SELECTED RAW MATERIAL REQUIREMENTS FOR JAPAN'S SPECIALTY STEEL INDUSTRY

By E. Chin,[1] John C. Wu,[2] L. Nahai,[1] Gordon L. Kinney,[1] and Charles L. Kimbell[1]

ABSTRACT

Although Japan is a major producer of crude steel, it is poor in industrial raw materials. This Bureau of Mines report describes Japan's raw material needs for chromium, cobalt, manganese, nickel, and tungsten to produce ferroalloys and alloy steels. Japanese imports of these ores or metals by quantity and source are given for 1972-81, inclusive, to indicate (1) the changes in the consumption and supply pattern, and (2) the degree of Japan's dependence on foreign sources. This report also describes measures implemented by Japan to reduce the risk of supply interruption, and discusses the possible implications of supply shortages.

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INTRODUCTION

Although Japan is poor in industrial raw materials and fuels, it ranks among the top manufacturing countries in the world. Of its metal industries, iron and steel play a crucial role in Japan's economy despite its overwhelming reliance on foreign sources of iron ore and coal. In 1982, Japan was the second largest world producer of crude steel. Moreover, downstream production of specialty steel[3] is likewise of world significance. For alloying ingredients, the ferroalloy and specialty steel sectors are similarly dependent on foreign raw materials. Japanese industry is totally dependent on imports for nickel and almost wholly so for cobalt. In addition, domestic mine production contributes only a modest share of the industrial requirement for chromium, manganese, and tungsten. Hence, severe limitations on securing raw material supplies of cobalt, chromium, manganese, nickel, and/or tungsten would affect Japan's industrial production, and in turn, would affect countries that import a substantial volume of Japanese manufactures containing these metals.

The bulk of Japan's ferroalloy supply is consumed in the production of various steel compositions; exports represent only a small percentage of demand. The United States has been the largest market for Japanese ferroalloys, but the share of total U.S. imports, never large, has been dwindling for the past decade. Japan exports a larger quantity of specialty steel, and exports to the United States have accounted for 30% to 40% of U.S. imports.

Exports of steel products, on the other hand, make a significant contribution to Japan's overall economy whether in the form of semimanufactures or as an integral component of finished goods. A fairly substantial share of these products is exported to the United States, and this constitutes a substantial part of total U.S. imports in these classes. Thus, the impact of any significant shortfall in the supply of cobalt, chromium, manganese, nickel, and tungsten would cause Japan to curtail exports of ferroalloys and specialty steel semimanufactures and to maintain the highest volume of exports of finished goods.

Because of its import dependency, the Japanese government and industries have adopted measures to cope with supply interruptions. These include diversification of supply sources and metal stockpiling. This report examines the impact of interruptions of raw material supplies to Japan's specialty steel industry and examines the subsequent impact on the United States.

OVERVIEW OF THE JAPANESE ECONOMY

Japan's economy ranked third in the world, with a gross national product (GNP) of $1,139.3 billion in 1981 (at Y220.54 = US$1.00). The GNP nearly doubled between 1965 and 1970, doubled between 1970 and 1975, and increased 70% between 1975 and 1981. Major industries are metallurgical and engineering, electric and electronic, textile, and chemical, all of which depend substantially on imported materials--ores and metals. The dependency is particularly great for minerals and fuels, which provide the basis for a gigantic processing and manufacturing industry for the domestic and export markets. Of total 1980 exports of $130.7 billion, 88% was manufactures (including 27% machinery, 23% motor vehicles, and 14% iron and steel). Manufacturing, mining, and construction accounted for 35%

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[3] In U.S. usage, specialty steel generally includes stainless steels, tool steels, high-speed steels, high-temperature alloys, superalloys, and miscellaneous special-use alloys. The Japanese data cited in this report also include indeterminant types and quantities of carbon alloy steels in the specialty steel classification.

of employment. For the same period, imports totaled $122.9 billion: 50% fossil fuels, 17% manufactures, 13% foodstuffs, and 8% machinery and equipment. Despite Japan's heavy reliance on fossil fuel imports, the country withstood the shock of substantially higher petroleum prices in 1974 and remained competitive in the world marketplace. This was achieved through monetary and fiscal policies such as curtailment of spending for public works, increased taxes, limits on credit expansion, and labor wage restraints. The economy also benefited from a sustained market for exports and an increase in labor productivity in the manufacturing sector. The index for labor productivity 1975=100 increased from 127 in 1978 to 142 in 1979, and to 160 in 1981. The total labor force grew from 55.3 million in 1978 to 57.1 million in 1981. The unemployment rate decreased from 2.2% in 1978 to 2.0% in 1980, but rose to 2.2% in 1981. The favorable trade balance in 1980 indicates that the second increase in oil prices of 1979 has also been taken in stride by the Japanese economy. Japanese goods and manufactures are expected to remain competitive in world markets and earn for Japan the funds needed for importing fuels and raw materials, as well as other requirements.

JAPAN'S MINERAL DEPENDENCY

Japan is dependent on imports of foreign ores and metals; the value of domestic mine output constitutes less than 1% of the GNP. Its self-sufficiency is limited largely to nonmetallics such as aggregates, bromine and iodine; and limestone, dolomite, and seawater magnesia. At the other extreme, Japan is 100% dependent on foreign sources of bauxite (aluminum), nickel, and titanium, and almost wholly dependent on foreign sources for chromium, iron, manganese, oil and natural gas, and uranium. Indigenous ores account for about 5% of the refined copper metal production, about 25% of the lead metal, and to about 35% of the zinc metal.

In contrast to the very low contribution of domestic mineral production to the GNP, the country's mineral processing and smelting industries account for about 19% of the GNP. In fact, industries that process minerals and produce metals, specifically iron and steel, nonferrous metals, and cement and nitrogenous fertilizers, are very large. Peak annual production during the 1970's includes the following, in million tons:[4] aluminum 1.1, copper 1.0, steel 119, ferroalloys 2.3, lead 0.2, zinc 0.9, and cement 87. With respect to fuels, Japan has had a peak production of 1,700 million 42-gal barrels of petroleum refinery products and 46 million tons of coke from imported and some domestic coal.

Securing a stable supply of overseas raw materials (specifically, ores and metals) at reasonable prices from as many different sources as possible has been a critical element of Japan's foreign economic and commercial policy. The section "Raw Material Policy" includes a brief outline of the measures taken by the government to implement the policy.

STATUS OF THE IRON AND STEEL INDUSTRY

Japan's steel industry paralleled the growth of its economy increasing from a crude steel production level of 4.8 million tons in 1950, to a peak of 119.3 million tons in 1973 (table 1). With anticipated output of 99.5 million tons in 1982, Japan ranked second as a producer of crude steel following the U.S.S.R.

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[4] Throughout this report, "tons" means "metric tons."

TABLE 1. - Iron and steel production, 1970-81, million tons

Year	Pig iron	Ferroalloys	Crude steel	Hot-rolled semimanufactures			
				Specialty steel	Other steel	Total	Share of specialty steel in total, %
1970	68.0	1.7	93.3	7.4	68.6	76.0	9.7
1971	72.7	1.9	88.6	6.9	65.2	72.1	9.6
1972	74.1	1.7	96.9	7.2	74.9	82.1	8.8
1973	90.0	2.0	119.3	9.1	92.6	101.7	8.9
1974	90.4	2.3	117.1	9.3	91.0	100.3	9.3
1975	86.9	2.1	102.3	8.0	77.9	85.9	9.3
1976	86.6	2.0	107.4	9.9	83.2	93.1	10.6
1977	85.9	1.8	102.4	10.3	79.6	89.9	11.5
1978	78.6	1.5	102.1	11.7	79.6	91.3	12.8
1979	83.8	1.9	111.7	12.5	89.1	101.6	12.3
1980	87.0	1.9	111.4	12.9	88.9	101.8	12.7
1981	80.0	1.6	101.7	13.3	79.8	93.1	14.3

During the first modernization program (1951-56) of the iron and steel industry, three integrated steelworks were completed: Chiba in 1951, Kure in 1952, and Hikari in 1955. Introduction of new technology by the industry included hot-rolled silicon steel sheet, hot strip rolling, continuous galvanizing, electrolytic tinning, and basic oxygen furnace (BOF) steelmaking. During the second and third modernization programs (1957-61) and (1962-66), five integrated steelworks were inaugurated: Nagoya in 1958, Mizushima and Sakai in 1961, and Fukuyama and Kimitsu in 1965. New technology introduced during this period included computer control, cold-rolled silicon steel sheet, vacuum degassing, controlled-pressure rolling, continuous casting, direct reduction, and blast furnace high-top-pressure operation. During 1967-68, construction of the Kashima, Keihin, Kakogawa integrated steelworks were completed, in that order. Japan's newest integrated steelworks is the Oita Works of Nippon Steel Corp., which was completed in 1971. Plant operation is completely computer controlled, and the mill features 100% continuous-casting operation. New technology introduced between 1967 and 1980 included blast furnace stove cooling, pelletizing, coke dry quenching, and bottom blown BOF steelmaking (Q-BOP). The integrated steelworks are coastally located, facilitating receipts of metal ores and coal from overseas suppliers. Raw materials discharged from giant carriers feed some of the world's largest (5,000-m^3) blast furnaces, which in turn feed large basic oxygen furnaces, and then modern rolling mills.

A substantial share of Japan's steel production (e.g., 32% in 1981) is exported. Although the United States and the European Community are the principal markets, Japan exports steel to dozens of countries on all continents.

STATUS OF THE FERROALLOY INDUSTRY

INDUSTRY STRUCTURE

In the past 5 years, the active Japanese ferroalloy industry has comprised about 35 companies, but 8 of these recorded no production in 1981. Of the remainder, 17 collectively accounted for over 90% of 1981 output of 10 major ferroalloy types, as indicated in table 2. Moreover, one of these firms, Pacific Metals Co. Ltd., together with four other firms not listed in the table, accounted for all ferronickel output, though the relative share of total provided by each is not available. The four unlisted firms are Nippon Yakin Kogyo Co., Ltd., Nippon Mining Co., Sumitomo Metal Mining Co., and Shimura Kako Co. Ltd.

TABLE 2. - Percentage share of ferroalloy output in 1981, by producer[1]

Company	Ferromanganese			Silico-manganese	Ferrochromium		Ferro-silicon	Ferro-molybdenum	Ferro-vanadium	Ferro-columbium
	High-carbon	Medium-carbon	Low-carbon		High-carbon	Low-carbon				
Nippon Denko KK	21.7	12.9	11.9	9.7	13.8	35.8	0	1.5	34.7	19.5
Japan Metals and Chemicals Co. Ltd	20.4	30.6	42.1	22.5	28.4	42.0	20.1	6.7	20.0	28.0
Chuo Denki Kogyo Co. Ltd	15.0	4.8	25.3	13.4	0	0	0	0	0	0
Nippon Kokan KK	9.8	18.7	.5	23.5	10.0	22.2	0	4.6	0	18.9
Pacific Metals Co. Ltd	6.8	.7	9.8	2.8	8.7	0	0	0	0	0
Mizushima Ferro Alloy Co., Ltd	18.8	22.0	0	15.0	0	0	0	0	0	0
Kobe Steel Ltd	7.5	7.6	4.1	7.9	0	0	0	0	0	0
Toyo Denka Kogyo KK	0	0	0	2.9	0	0	11.9	0	0	0
Yahagi Seitetsu KK	0	0	0	0	0	0	22.5	0	0	0
Showa Denko KK	0	0	0	0	24.0	0	0	7.3	0	0
Ube Kosan Co., Ltd	0	0	0	0	0	0	12.6	0	0	0
Awamura Metal Industry Co., Ltd	0	0	0	0	15.1	0	0	24.7	18.2	20.7
Taiyo Mining & Industrial Co	0	0	0	0	0	0	0	14.6	27.1	12.9
Taenaka Mining Co	0	0	0	0	0	0	0	40.6	0	0
Nippon Keiso Kogyo KK	0	0	0	0	0	0	8.7	0	0	0
Denki Kagaku Kogyo KK	0	0	0	0	0	0	8.1	0	0	0
Yakushima Denko Co. Ltd	0	0	0	0	0	0	8.1	0	0	0
Other	0	2.7	6.3	2.3	0	0	8.0	0	0	0
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

[1]Excludes producers of ferronickel.

As in most other market economy nations, Japan's major ferroalloy producers by and large are not major steel producers. Of the firms listed in the table, only Nippon Kokan KK and Kobe Steel Ltd. rank as major integrated steel producers; of the ferronickel firms, only Sumitomo (through its affiliation with Sumitomo Metal Industries) could be regarded as connected with a major steel firm.

PRODUCTION

As shown in table 3, Japan produces a virtually complete range of ferroalloys, principally for domestic production of alloy steel rather than for the export market. In terms of tonnage, the manganese ferroalloys (ferromanganese and ferrosilicomanganese) are the largest category, accounting for over 49% of total output, during 1972-81, inclusive, followed by the chromium ferroalloys (ferrochromium and ferrosilicochromium) with nearly 22% of the total for the same period. Next in importance, and the only other substantial types are ferrosilicon, with 16% of the total, and ferronickel with 12%; all others together account for less than 1% of total 1972-81 output.

Total ferroalloy production in Japan reached a record high in 1974, the year after its record high in crude steel output level. Ferrochrome, ferrosilicon, and ferrosilicomanganese reached maximum output levels in 1974; thereafter, their production turned generally downward and, although there were individual recoveries from time-to-time, these ferroalloys did not reach new record highs from 1975 through 1981. Ferromanganese production peaked in 1975, then generally turned downward, with 1978 being a particularly poor year. Unlike the other major ferroalloys, ferronickel output reached a record high in 1979, following a less prominent peak in 1974. Among the minor alloys, the years of record output seem less clearly defined.

TRADE

Table 4 summarizes Japan's imports and exports of ferroalloys during 1972-81. A clear shift occurred between the first 5 years of the decade and the last 5 years: Japan changed from a modest net exporter to a large net importer. During 1972-76, exports (totaling nearly 805,000 tons) exceeded imports by 146,000 tons; in contrast, during 1977-81, imports (totaling nearly 2,036,000 tons) exceeded exports by nearly 1,631,000 tons.

SUPPLY

Domestic production of ferroalloys, overwhelmingly from imported raw materials, accounted for 87.5% of total new supply (domestic output plus imports) of these important materials during 1972-81, inclusive. Of these materials, imports, although quantitatively substantial, represented only a relatively modest share of that supply for the decade. A sharp shift in the supply pattern began in late 1977 and resulted in more than doubling the import share of the 1978 total. The following tabulation shows the percentage of the total new supply of ferroalloys contributed by domestic production and by imports:

Year	Domestic production	Imports
1972	96.7	3.3
1973	93.4	6.6
1974	92.4	7.6
1975	96.0	4.0
1976	91.8	8.2
1977	90.5	9.5
1978	80.7	19.3
1979	79.1	20.9
1980	79.6	20.4
1981	76.5	23.5
Weighted average	87.5	12.5

TABLE 3. - Ferroalloy production for 1972-81, by type, tons

Ferroalloy	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
Ferrochromium:										
High-carbon........	224,302	357,414	450,969	387,057	373,644	353,253	241,685	321,125	349,940	265,886
Low-carbon.........	78,330	85,618	90,967	99,910	89,897	45,529	32,736	44,365	53,057	40,218
Total..........	302,632	443,032	541,936	486,067	463,541	398,782	274,421	365,490	402,997	306,104
Ferrochromium-silicon	27,566	18,208	14,679	25,199	11,046	11,411	[1]9,208	[1]12,623	[1]20,531	[1]10,469
Ferrocolumbium.......	0	0	0	0	1,608	1,281	1,193	1,207	1,159	825
Ferromanganese:										
High-carbon........	439,208	478,842	492,623	515,409	485,535	399,324	367,756	449,228	452,546	450,120
Low-carbon.........	114,096	137,662	131,546	134,325	146,625	128,094	87,973	153,791	116,601	117,626
Total..........	553,304	616,504	624,169	649,834	632,160	527,418	455,729	603,019	569,147	567,746
Ferromolybdenum......	2,214	2,594	3,682	3,928	4,501	3,705	3,904	3,406	4,367	3,056
Ferronickel..........	188,776	200,444	251,232	200,569	198,411	224,339	198,482	303,716	276,829	244,135
Ferrophosphorus......	2,719	2,974	2,243	([2])	([2])	([2])	([2])	([2])	([2])	([2])
Ferrosilicocalcium...	8,623	7,355	6,412	5,112	3,898	5,634	1,896	3,349	3,859	2,590
Ferrosilicon.........	309,233	353,758	368,948	327,478	313,077	291,446	270,052	319,553	303,754	234,524
Ferrotungsten........	611	934	776	494	447	371	243	251	242	362
Ferrovanadium........	2,440	3,117	3,261	3,165	3,901	2,546	3,193	4,628	3,526	4,063
Silicomanganese......	343,107	376,323	448,126	435,107	373,196	333,692	303,249	299,680	310,714	282,852
Other, n.e.s.........	1,928	9,718	1,514	[2]2,435	[2]2,061	[2]7,352	[2]9,637	[2]9,298	[2]10,360	[2]3,167
Total..........	1,743,153	2,034,961	2,266,878	2,139,388	2,007,847	1,807,977	1,512,791	1,900,974	1,866,423	1,638,955

[1]Reported as a negative number in source.
[2]Ferrophosphorus included in other ferroalloys 1975-81, inclusive.

TABLE 4. - Ferroalloy trade for 1972-81, by type, tons

Ferroalloy	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
Imports:										
Ferrochromium...........	14,409	31,371	38,815	29,104	93,002	104,098	168,697	250,317	257,157	189,928
Ferrochromium-silicon...	([1])	([1])	([1])	([1])	13,657	5,497	5,951	23,046	23,210	9,764
Ferrocolumbium..........	([1])	([1])	([1])	([1])	1,723	905	1,177	1,989	1,419	1,586
Ferromanganese..........	220	22,080	16,153	1,900	1,850	5,777	17,017	18,758	2,662	6,505
Ferromolybdenum.........	516	2,291	2,172	646	1,036	222	651	547	448	266
Ferronickel.............	6,662	11,718	18,001	9,858	14,307	19,858	20,485	33,152	31,119	26,493
Ferrosilicon............	17,130	47,853	70,658	33,905	46,717	45,293	100,316	133,494	122,012	196,487
Ferrotungsten...........	53	598	231	121	555	209	118	483	186	45
Ferrovanadium...........	([1])	([1])	([1])	([1])	1,559	296	1,692	1,265	306	830
Other...................	20,678	26,943	40,624	14,654	4,708	8,265	45,185	40,745	38,774	71,120
Total..............	59,668	142,854	186,654	90,188	179,114	190,420	361,189	503,796	477,293	503,024
Exports:										
Ferrochromium...........	22,977	17,214	57,578	85,228	54,509	16,307	6,365	19,852	8,896	3,470
Ferromanganese..........	50,472	26,412	54,265	130,625	121,934	48,634	37,147	92,886	40,271	34,866
Ferronickel.............	19,053	1	2,274	4,566	13,262	2,268	21,773	13,193	17,125	20,742
Ferrosilicon............	2,703	1,781	22,574	26,163	8,224	2,972	2,336	2,003	2,695	2,199
Ferrotitanium...........	395	72	196	116	([1])	([1])	([1])	([1])	([1])	([1])
Ferrovanadium...........	188	150	115	54	39	13	71	13	97	84
Silicomanganese.........	7,020	1,433	36,002	8,933	9,863	3,112	342	2,377	420	1,158
Other...................	3,505	3,248	4,063	4,525	2,995	2,502	2,266	2,121	1,035	1,318
Total..............	106,313	50,311	177,067	260,210	210,826	75,808	70,300	124,533	70,539	63,837

[1]Included in "Other."

This increasing dependence on the import of ferroalloys, as opposed to import of the ores of these metals, is considered to be primarily the result of differences in relative costs of energy for production of the ferroalloy and for transport of the processed materials. These costs reflect the producing countries' desire to export value-added material.

Considering those ferroalloys that can be clearly identified in both production and import statistics, there are substantial differences in the shares of total supply that are met by imports and by domestic production, both from commodity to commodity and across the 10-year period 1972-81. The following tabulation demonstrates that, in terms of total new supply, ferromanganese, ferronickel, and ferrosilicon have been produced chiefly in Japan rather than being imported as the finished ferroalloy. However, in each of these cases, there has been a small trend toward increasing the dependence upon ferroalloy imports in the second half of the decade. The tabulation shows domestic production and imports for two successive 5-year periods and for the 10-year period, in percent of total new supply:

Ferroalloy	1972-76		1977-81		1972-81	
	Domestic production	Imports	Domestic production	Imports	Domestic production	Imports
Ferrochromium.........	91.5	8.5	64.3	35.7	70.5	29.5
Ferrochromium-silicon.	[1]44.7	[1]55.3	48.8	51.2	[2]48.1	[2]51.9
Ferrocolumbium........	[1]48.3	[1]51.7	44.5	55.5	[2]45.2	[2]54.8
Ferromanganese........	98.6	1.4	98.2	1.8	98.4	1.6
Ferromolybdenum.......	71.8	28.2	89.6	10.4	80.1	19.9
Ferronickel...........	94.5	5.5	90.5	9.5	92.3	7.7
Ferrosilicon..........	88.5	11.5	70.4	29.6	80.0	20.0
Ferrotungsten.........	67.7	32.3	58.5	41.5	64.5	35.5
Ferrovanadium.........	[1]65.0	[1]35.0	75.6	24.4	[2]78.6	[2]21.4
All ferroalloys.......	93.9	6.1	81.1	18.9	87.5	12.5

[1]Data for 1976 only (imports not reported separately 1972-75).
[2]Data for 1976-81 only (imports not reported separately 1972-75).

Of these ferroalloys, only ferrosilicon is produced chiefly from domestic raw materials; output of ferromanganese is heavily dependent upon imported ore, and ferronickel is wholly dependent upon imported ore.

The tabulation further shows that imports of ferrochromium constituted only 8.5% of the total new supply during 1972-76 but 35.7% during 1977-81. Among the less common ferroalloys, import receipts of ferrocolumbium, ferrochromium-silicon, and ferrotungsten have represented a substantial part of total new supply throughout 1972-81, generally with the share edging higher in the latter half of the period. In contrast, ferromolybdenum and ferrovanadium showed a measurable downturn, when comparing the first 5 years with the second 5 years.

Ferrosilicomanganese is the only ferroalloy produced in substantial amounts in Japan for which separate import statistics are not available; consequently, the precise share of total supply provided by import of the finished ferroalloy cannot be determined. The amount of ferrosilicomanganese imported could be less than 10% of the newly available supply for the 1972-81 decade.

Exports of ferroalloys from Japan never represented a substantial share of new supply during 1972-81, averaging only 5.6% for the entire period, and varying between a high of 11.7% in 1975 and a low of 2.3% in 1973. Table 4 summarizes these exports by type. The United States was the principal destination for these ferroalloy exports, accounting for over half of the total for 1972-81. However, these exports are merely a small part of Japan's new supply of ferroalloys, and are generally declining; the U.S. share of the total has also diminished. The following tabulation shows the declining share of total new supply destined for export, the share of total ferroalloy exports destined for the United States, and the Japanese share of total U.S. ferroalloy imports, in percent:

Year	Share of Japanese total supply[1] of all ferroalloys exported	Share of total Japanese export destined for United States	Share of total U.S. import provided by Japan
1972	5.9	62.6	8.0
1973	2.3	60.8	4.8
1974	7.2	66.5	6.9
1975	11.7	58.1	20.8
1976	9.6	63.7	12.6
1977	3.8	48.7	5.7
1978	3.8	28.7	1.6
1979	5.2	29.6	3.1
1980	3.0	25.9	2.0
1981	3.0	35.3	1.6

[1]Production plus imports

CONSUMPTION

The alloy and specialty steel industry of Japan is the principal consumer of ferroalloys available to the Japanese economy. Consumption data for most of these commodities by Japan's steel industry during 1972-81, inclusive, appear in table 5. It is assumed that virtually all of the tonnages of ferrochromium and ferromolybdenum shown in the table were used in the production of stainless steels, as were 200,000 to 300,000 tons of ferronickel per year (based on apparent consumption computations, in lieu of a reported consumption). The other ferroalloys shown presumably were used in producing other types of specialty steel, such as electrical steel.

Significantly, the general trend in ferroalloy consumption does not parallel the trend in crude steel production. Although steel output peaked in 1974, the record consumption for ferroalloys occurred in 1980, totaling 2 million tons (includes an apparent consumption of 290,000 tons of ferronickel). The annual configuration by type of steel produced changed during 1974-80. In this period, a larger percentage of the annual steel output was in the form of alloy steel. Moreover, production of hot-rolled alloy steel reached a new record high in 1981.

RAW MATERIAL REQUIREMENTS AND SUPPLIES

Chromium

Salient statistics of chromium are shown in table 6. Although Japan has produced chromite domestically, the output in terms of its requirements is insignificant.

TABLE 5. - Ferroalloy consumption for steel production, 1973-81, tons

	1973	1974	1975	1976	1977	1978	1979	1980	1981
Ferrochromium:									
High-carbon	397,878	377,876	298,368	421,861	442,976	436,190	538,684	540,374	452,306
Low-carbon	83,124	83,341	48,248	44,740	40,330	37,880	41,290	46,178	39,300
Total	481,002	461,217	346,616	466,601	483,306	474,070	580,974	586,552	491,606
Ferrochromium-silicon	51,221	42,859	30,234	28,867	16,997	6,560	5,439	4,449	3,392
Ferromanganese:									
High-carbon	466,246	447,990	374,792	368,683	363,578	383,025	416,120	425,807	417,442
Low- and medium-carbon	89,075	89,430	80,927	91,161	82,502	76,460	83,143	92,173	94,791
Total	555,321	537,420	465,719	459,844	446,080	459,485	499,263	517,980	510,233
Ferromolybdenum and related materials:									
Ferromolybdenum	3,975	5,190	4,681	4,347	4,318	4,016	3,583	3,587	3,386
Molybdenum briquet	10,407	11,598	8,603	11,220	9,788	12,216	13,035	14,007	14,083
Ferrosilicon	270,497	276,357	223,070	251,948	237,647	252,650	283,407	296,372	280,125
Ferrovanadium	3,378	3,683	3,653	4,357	4,190	4,184	5,235	4,643	5,143
Silicomanganese	380,466	400,649	378,619	371,115	345,562	336,844	353,589	344,006	322,215

TABLE 6. - Salient chromium statistics, thousand tons

	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
Raw material supply:										
Domestic production of chromite:										
Gross weight	25	23	26	23	22	18	9	12	14	11
Chromium content	8	8	9	8	7	6	3	4	4	4
Imports:										
Chromite:										
Albania	0	7	0	58	3	27	0	22	0	31
Brazil	40	36	15	0	0	71	72	51	18	0
India	154	221	311	360	238	138	73	156	170	142
Iran	25	12	64	52	78	54	26	(1)	0	0
Madagascar	19	0	60	58	134	66	32	62	32	0
Philippines	78	115	127	153	149	41	74	184	208	151
South Africa, Republic of	445	619	424	343	416	373	350	443	407	348
Turkey	10	45	0	98	84	15	10	0	27	6
U.S.S.R.	104	95	123	95	59	48	25	16	39	40
Other	0	14	31	52	56	67	8	28	49	26
Total	875	1,164	1,155	1,269	1,217	900	670	962	950	744
Chromium oxide and hydroxide	1	2	2	1	3	3	4	3	2	2
Ferrochromium:										
Brazil	0	0	0	0	3	0	28	28	23	28
India	0	0	0	0	0	3	7	2	1	4
South Africa, Republic of	14	28	34	29	90	79	120	203	202	126
United States	(1)	3	5	0	0	12	0	0	16	3
Zimbabwe	0	0	0	0	0	0	0	0	10	21
Other	(1)	(1)	(1)	0	0	10	14	17	5	8
Total	14	31	39	29	93	104	169	250	257	190
Ferrochromium-silicon:										
South Africa, Republic of	(2)	(2)	(2)	(2)	9	5	6	0	10	2
Zimbabwe	(2)	(2)	(2)	(2)	0	0	0	23	10	7
Other	(2)	(2)	(2)	(2)	4	(1)	(1)	(1)	3	1
Total	(2)	(2)	(2)	(2)	14	5	6	23	23	10
Approximate chromium content of all imports[e]	400	500	530	580	600	460	400	580	570	450
Processing:										
Use of chromite:										
In ferroalloy and iron and steel industries	NA	984	1,049	966	848	774	523	648	798	594
In chemical, refractory, and other industries[3]	NA	144	224	282	338	107	199	295	NA	NA
Production of ferrochromium:										
High-carbon	224	357	451	387	374	353	241	321	350	266
Low-carbon	79	86	91	99	90	46	33	44	53	90
Total	303	443	542	486	464	399	274	365	403	306
Production of ferrochromium-silicon	28	18	15	25	11	11	9	13	21	10
Production of chromium metal	2	2	2	3	2	3	3	3	4	4
Exports:										
Chromite	0	(1)	(1)	(1)	2	3	2	2	6	1
Chromite oxide and hydroxide	2	2	1	1	1	2	2	2	3	2
Ferrochromium:										
To United States	18	12	31	57	32	5	2	2	3	1
Other	5	5	27	28	23	11	4	18	6	2
Total	23	17	58	85	55	16	6	20	9	3

NA Not available.
[e] Estimated.
[1] Less than 1/2 unit.
[2] Not reported separately.
[3] Calculated by subtracting reported industry figure from reported total.

Total reserves of chromite in Japan were estimated at 325,500 tons averaging 32% Cr_2O_3 in 1979, of which about 39% represented demonstrated reserves. The deposits occur mainly in the Iburi and Hidaka districts of southern Hokkaido, and in the Chugoku region of western Honshu; a small chromite placer deposit occurs in northern Hokkaido. Up to 11 mines have operated in these areas at various times.

The peak production of chromium in Japan occurred in 1939 when military needs required mine production from submarginal domestic resources. Production dropped to 2,400 tons in 1947, but then rose intermittently, reaching a high of 70,000 tons in 1961. Since then, there has been a downward trend in mine output as reserves were depleted and as mining costs rose. In 1981, three mines (Hirose, Wakamatsu, and Takase) produced a total of about 11,000 tons of chromium concentrate. This ore supplied less than 2% of the domestic demand for chromium.

Japan's requirements for chromium are met principally by imports of chromite as well as ferrochromium. The latter is also produced in Japan from imported ore. High-carbon ferrochromium dominates Japan's production. Of the 306,000 tons of ferrochromium production in 1981, 87% was high-carbon and 13% low-carbon. The increase in imports of ferrochromium has idled some of domestic production. At least one ferrochromium producer went out of business in 1977.

Two companies produce chromium metal in Japan: Toyo Soda Manufacturing Co., which has a 3,600-ton-per-year capacity, and Nippon Denko (700 tons per year). From 60% to 70% of Japanese chromium metal production is usually exported, principally to the United States and Western Europe. Because of extensive metallurgical uses, the total annual quantity imported varies directly with demand in the steel industry. During the past two decades, a high of 1,269,000 tons of chromite was imported in 1975 and a low of 670,000 tons was imported in 1978. Principal sources of chromite imports are shown in table 6. In 1981 imports were predominately from the Republic of South Africa, followed by the Philippines and India; these countries accounted for over 86% of Japan's chromite imports. Much of the chromite imported from the Philippines is refractory grade.

Japan's imports of chromium ore are being replaced increasingly by those of ferrochromium. These imports increased from 29,000 tons in 1975 and 104,000 tons in 1977 to peak imports of 257,000 tons in 1980. Twelve countries have supplied Japan with ferrochromium, but the major source has been South Africa, with Brazil ranking second in recent years.

Chromite is used in the production of ferrochromium, which is used for making stainless steel; a smaller tonnage is used for making other types of specialty steel and alloys. Other users are the chemical industry (pigments, leather tanning, and electroplating) and the refractory industry (for basic furnace lining). The metallurgical industry's consumption of chromium is about one and a half times consumption of all other uses combined. Stainless steel production accounts for about 70% of contained chromium used by the metallurgical industry. Japan is a leading world producer of stainless steel, with a production of over 1.8 million tons in 1980 and 1.54 million tons in 1981.

Cobalt

Japan has an annual refinery capacity for production of 2,800 tons of cobalt. To meet demands, some cobalt is recovered as a byproduct of domestic ore processing by Sumitomo Metal Mining Co. Ltd. and by Nippon Mining Co. Ltd. An additional supply comes from the recovery of cobalt by Mitsubishi Metals Corp. from copper sulfide ores at the Hokkaido plant of Shimkawa Mining. About 75% of the refinery output of cobalt is estimated to be from imported material; the remainder comes from domestic ore. About 20% of the cobalt from overseas sources is toll refined and exported; the rest is sold and shipped to domestic purchasers such as the electronics industry and specialty steel producers.

Imports of cobalt oxide, hydroxide, metal, and other forms are shown in table 7. Until the mid-1970's, Japan imported about 90% of its cobalt metal requirements from Zaire (includes that metal credited to Belgium in table 7). In most cases, cobalt was imported by a Japanese trading company, which negotiated long-term contracts with Société Générale des Minéraux (SGM) of Belgium. Since 1976, Japan has increased its production of cobalt by importing mixed nickel-cobalt sulfide from Australia and the Philippines and refining it domestically (by Sumitomo Metal Mining Co. Ltd. and Nippon Mining Co. Ltd.). In terms of recovered metal content, the Philippines has been the most important source. Japan's imports of nickel- and cobalt-bearing ores, concentrates, mattes, and sulfides, and principal sources of supply for 1972-81 are tabulated in the section on nickel.

In 1981, Japan produced 2,421 tons of refined cobalt, imported 868 tons, and exported an estimated 400 tons. Consumption was 1,511 tons; peak consumption was 3,924 tons in 1973. Magnetic alloys, of which aluminum-nickel-cobalt alloys represent the largest composition type, account for nearly 30% of total domestic consumption of cobalt. About 18% of consumption is in specialty steel (e.g., high-speed and heat-resistant alloys); 10% in ultrahard alloys; 7% in catalysts; 20% in manufacturing pipe, sheet, bar, and wire for machinery and transport equipment industries; and the remaining 15% in chemical and other industries.

Cobalt consumption in Japan has declined annually since 1976. The decline was attributed to higher prices rather than lack of supply. End-use sectors showing a marked decrease in consumption of cobalt were those of specialty steel and magnets, resulting from substitution and use of less cobalt in finished materials. There was however, a significant constancy in the consumption of cobalt in ultrahard machine tools, catalysts, and unspecified, distributive, and/or dissipative applications.

Manganese

Japan's manganese resources are not large by world standards. The aggregate sources of metallurgical-grade ore, from a number of widely separated sites, are on the order of 3 million tons, containing 658,000 tons of recoverable manganese. Battery- and chemical-grade ore reserves probably total 40,000 to 50,000 tons of recoverable manganese content. Ore quality and reserves are of marginal value, causing mines to close periodically in response to market conditions. As a result, domestic mines have supplied only a small percentage of Japan's total needs.

Production of manganese was first reported in 1902 and increased slowly to 356,000 tons of concentrates in 1944. Production has declined steadily, from 339,000 tons in 1967 to about 87,000 tons in 1981. The average crude ore grade has declined to about 14% manganese. Small amounts of higher quality material have been mined and concentrated for use in the dry-cell and chemical industries. Several companies have reported production in varying amounts from different mines. In 1981, three domestic companies produced manganese ore: Chuugnai Mining Co. Ltd., Hama Mining Co. Ltd., and Hokushin Mining Co. Ltd.

Japan depends almost entirely on imports of manganese ore for its steel industry. It is estimated that the Japanese steel industry absorbs 8% of the world's mine output of manganese ore. Japan's imports of manganese ore and other manganese-bearing materials for 1972-81 are shown in table 8. In the early 1960's, Japan imported annually about 400,000 tons of manganese ore. As its iron and steel industry expanded, imports of manganese ore and ferruginous manganese ore increased to about 1 million tons in 1965 and to almost 4 million tons by 1975. Although more than 16 countries have supplied manganese ore to Japan during 1972-81, in the last 5 years, Australia and the Republic of South Africa have accounted for 72% to 82% (excluding ferruginous manganese ore).

TABLE 7. - Salient cobalt statistics, tons

	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
Imports:[1]										
Cobalt oxide:										
Belgium	586	785	726	204	616	406	435	477	150	90
Canada	12	6	0	0	18	52	52	31	8	20
United States	0	0	([2])	([2])	26	28	20	23	14	4
Other	4	3	5	0	14	16	21	15	21	19
Total	602	794	731	204	674	502	528	546	193	133
Cobalt hydroxide:										
Belgium	82	149	81	46	73	79	87	105	99	79
Other	0	0	7	2	7	16	0	0	0	15
Total	82	149	88	48	80	95	87	105	99	94
Unwrought cobalt metal:[3]										
Belgium	366	328	389	120	236	540	290	329	464	246
Finland	136	100	121	42	90	117	88	53	43	96
United States	215	823	105	41	165	48	82	102	169	139
Zaire	2,049	3,626	2,914	1,272	2,658	1,011	679	749	672	210
Zambia	0	0	0	0	482	6	1	20	5	13
Other	58	113	132	57	203	143	97	132	129	177
Total	2,824	4,490	3,661	1,532	3,834	1,865	1,237	1,385	1,482	868
Waste and scrap cobalt:										
United States	82	123	27	32	64	89	49	172	166	166
Other	42	22	0	16	33	129	65	112	44	40
Total	124	145	27	48	97	218	114	284	208	206
Wrought cobalt:[4]										
United States	2	16	25	1	1	1	7	6	5	5
Other	2	6	3	([2])	([2])	1	([2])	2	3	2
Total	4	22	28	1	1	2	7	8	8	7
Estimated cobalt content of all imports[5]	3,460	5,350	4,330	1,810	5,010	3,620	3,670	4,810	4,770	3,670
Processing: Production of cobalt metal	0	0	10	48	515	1,093	1,864	2,653	2,867	2,421
Exports:[6]										
Cobalt oxide and hydroxide exports:										
Total	5	16	12	12	11	10	87	41	85	13
To United States	0	0	0	0	([2])	0	1	2	0	0
Cobalt, unwrought, including waste and scrap:										
To France	0	0	0	0	0	0	5	23	157	99
To Germany, Federal Republic of	0	0	0	0	0	0	12	94	275	75
To United States	20	2	0	1	21	25	195	305	564	737
Other[7]	0	0	0	0	0	0	1	5	44	NA
Total	20	2	0	1	21	25	213	427	1,040	911

NA Not available.

[1]The principal crude source of cobalt metal recovered in Japan is cobaltiferous nickel ore; lesser amounts may be recovered from cobaltiferous copper ores. For data on imports of cobaltiferous nickel ore, see table 9. Additional cobalt undoubtedly is imported in nickel matte, and other intermediate nickel metallurgy, but the cobalt content of imported matte is not available, nor can it be reliably estimated from available information.

[2]Less than 1/2 unit.

[3]Includes powder and flake.

[4]Includes unknown quantities of not specifically identified "oxides of cobalt" for 1976-81, inclusive.

[5]Includes figures for estimated recoverable content of imported and domestically produced cobaltiferous ores and intermediate metallurgical products; these estimates are based on Japanese metal production, which began in 1974.

[6]Japan does not record separately its exports of cobalt metal; data presented here for cobalt metal are recorded imports from Japan by listed trading partner countries.

[7]Belgium-Luxemburg, Denmark, Ireland, Italy, the Netherlands, and the United Kingdom only.

TABLE 8. - Salient manganese statistics, thousand tons

	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
Raw material supply:										
Manganese ore production:										
Gross weight	261	189	167	158	142	126	104	88	80	87
Mn content	72	53	42	39	33	33	29	23	21	21
Imports:										
Manganiferrous iron ore:										
India	61	29	36	22	11	26	16	7	0	18
South Africa, Republic of	0	18	99	70	11	0	27	0	0	0
Total	61	47	135	92	22	26	43	7	0	18
Ferruginous manganese ore:										
China	14	30	44	41	32	45	38	39	16	16
India	657	651	811	641	536	523	483	459	516	390
South Africa, Republic of	615	840	1,001	904	799	704	383	520	538	532
Thailand	0	0	0	6	20	66	48	40	37	22
U.S.S.R.	0	0	101	143	90	89	0	0	0	0
Other[1]	48	38	53	36	41	20	0	0	0	0
Total	1,334	1,559	2,010	1,771	1,518	1,447	952	1,058	1,107	960
Manganese dioxide ore:										
Australia	0	0	0	([2])	0	4	4	5	11	4
China	2	([2])	2	1	1	3	3	3	3	2
Gabon	1	0	4	8	0	2	4	2	8	4
Indonesia	5	0	8	2	2	2	2	2	([2])	0
Other	9	0	8	([2])	1	1	([2])	([2])	5	1
Total	17	([2])	22	11	4	12	12	12	27	11
Other manganese ore:										
Australia	506	626	652	655	804	500	444	544	602	429
Brazil	45	29	22	54	42	42	51	162	149	111
China	22	9	11	3	4	2	2	2	3	1
Congo	1	4	20	7	14	53	28	16	21	0
Gabon	248	208	113	166	207	70	60	122	150	58
Ghana	23	18	54	47	19	10	25	31	46	25
India	65	44	33	29	29	20	0	0	3	0
Mexico	45	60	94	130	129	103	75	73	80	67
South Africa, Republic of	461	636	682	703	467	420	310	660	761	829
U.S.S.R.	71	54	20	15	11	18	25	0	0	0
Vanuatu	32	64	116	134	39	25	22	10	3	0
Other	50	64	116	134	57	31	6	2	2	2
Total	1,569	1,785	1,876	1,958	1,834	1,294	1,048	1,622	1,820	1,522
Ferromanganese:										
India	0	22	16	0	0	5	15	12	2	3
Other	([2])	([2])	0	2	2	1	2	7	1	4
Total	([2])	22	16	2	2	6	17	19	3	7
Estimated manganese content of all imports	1,080	1,240	1,440	1,380	1,230	990	750	1,020	1,110	940
Processing:										
Production of ferromanganese:										
High-carbon	439	479	493	515	485	399	368	449	452	450
Low-carbon	114	138	131	135	147	128	88	154	117	118
Total	553	617	624	650	632	527	456	603	569	568
Production of ferrosilicon manganese	343	376	448	435	373	334	303	300	311	283
Production of manganese metal	13	10	9	8	7	7	6	4	4	4
Exports:										
Manganese ore:										
Total	3	2	5	4	6	5	5	6	2	1
To United States	0	0	1	0	0	0	0	0	0	0
Manganese dioxide:										
Total	41	39	36	23	34	24	22	19	23	27
To United States	4	2	2	1	3	4	4	3	6	12
Ferromanganese:										
Total	50	26	54	131	129	49	37	88	40	35
To United States	38	17	39	86	91	30	([1])	31	12	7

[1]All from Malaysia except 23,000 tons in 1972 from Romania.
[2]Less than 1/2 unit.

High-grade imported manganese ore is used for the production of ferromanganese and silicomanganese. Consumption for this purpose is about 1.4 million tons annually. Between 500,000 and 600,000 tons of ferromanganese and about 300,000 to 400,000 tons of silicomanganese were produced annually in the 1970's. Of the total ferromanganese produced during 1973-81, about 78% was high-carbon and 22% was low-carbon ferromanganese. A small tonnage of ferromanganese is also imported, mainly from India.

Ferruginous manganese ores, which are also imported in large tonnages, are ores with 10% to 30% manganese and a high iron content. Most of the ferruginous ores are used in blast furnaces in the production of pig iron, with only a small portion used as raw material for ferroalloy plants. India and South Africa together have supplied 90% to 95% of this material since 1975. During the 1970's, Japan's iron and steel industry consumed annually about 1.4 million tons of ferruginous manganese ore as direct blast furnace feed and raw material for making sinter. During 1973-79, about half of the total ferruginous manganese ore consumed was used for sinter feed; the remainder went directly to blast furnace.

About 95% of Japan's total demand for manganese is by the iron and steel industry. High-grade manganese ore is used for the production of refined ferromanganese (high-carbon and low-carbon). Japan's steel industry consumed an annual average of about 600,000 tons of ferromanganese and about 300,000 to 400,000 tons of ferrosilicomanganese during 1972-81 (491,000 tons of contained manganese in 1981). Each ton of crude steel consumes an average of 3.76 kg of high-carbon ferromanganese, 0.75 kg of medium- and low-carbon ferromanganese, and 3.31 kg of ferrosilicomanganese. The world recession that followed the oil crisis in 1973-74 resulted in cutbacks in steel production and, consequently, a decline in ferroalloy consumption.

Japan consumes between 60,000 and 90,000 tons of high-grade manganese ore annually for the production of electrolytic manganese, which is used to make specialty steel and to make manganese dioxide for the manufacture of dry-cell batteries. Only a few ores can be used for making dry-cell batteries, and high manganese content alone does not make the ore suitable. Although a small percentage of Japanese ore has the required properties for beneficiation into battery-grade material, Japan is dependent on imports for this material. Four companies reported an aggregate production of 44,295 tons of electrolytic manganese dioxide in 1981.

Japan's annual capacities for manganese ferroalloys and dioxide in 1981 were ferromanganese 941,900 tons, silicomanganese 597,200 tons, and manganese dioxide 52,800 tons. Principal domestic firms producing ferromanganese and silicomanganese are listed in table 2. Producers of manganese dioxide include Toyo Soda Industries Co. Ltd. (24,000-ton-per-year capacity), Mitsui Mining Smelting Co. Ltd. (19,200-ton-per-year capacity), Japan Metal and Chemical Industries Co. (6,000-ton-per-year capacity), and Dai-ichi Carbon Co. (3,000-ton-per-year capacity).

Japan's production of electrolytic manganese metal in the 1972-81 decade has ranged from a high of 12,657 tons in 1972 to a low of 4,232 tons in 1981. Currently, two firms produce the metal: Chuo Denki Kogyo Co., which sells the metal only in the domestic market, and Toyo Soda Co., which sells both domestically and overseas. Exports of the metal accounted for over 60% of the production in 1978 but only 4% in 1981. The United States is the principal market; other importing countries are Brazil, France, the Federal Republic of Germany, and Canada.

Nickel

Japan is a major world consumer of nickel. All consumption requirements are met by imports of nickel ore, nickel matte, nickel-cobalt mixed sulfides, nickel oxide, ferronickel, and nickel metal (including scrap). Imports of these commodities in the 1972-81 decade are shown in table 9. The combined total of the annual imports for 1972-81 are 3 to 4 million tons of nickel ore from Indonesia, New Caledonia, and the Philippines; 13,000 to 52,000 tons of nickel matte, speiss, and other intermediate products from Australia, Indonesia, and New Caledonia; and 8,000 to 19,000 tons of ingots, 7,000 to 33,000 tons of ferronickel, and smaller tonnages of other forms from various countries. The ores are used for making ferronickel; other forms (matte, speiss, and other intermediate products) are used for making the metal. Japan's production of ferronickel and metal for 1972-81 is shown in table 9. The production of ferronickel has varied between 200,000 and 300,000 tons (gross weight) and production of nickel metal has been about 24,000 tons per year. The producers of ferronickel were listed previously under Industry Structure; nickel metal was produced by Sumitomo Metal Mining Co. and Nippon Mining Co. Ltd., with an annual capacity of 22,780 tons and 4,100 tons, respectively. These two companies accounted for the 23,800 tons of nickel produced in 1981.

In 1981, ferronickel consumption totaled about 258,000 tons (gross weight). About 90% of the total ferronickel supply was used indigenously for the production of stainless and other alloy steels; most of the remainder was exported. In 1981, a total of 1.5 million tons of stainless steel was produced, of which 1 million was nickel-based stainless. The about 34,000 tons of nickel metal consumed in 1981 was distributed as follows: specialty steel, 38%; plating, 20%; nonferrous alloys, 17%; magnetic materials, 7%; and other uses, 18%. To supplement domestically produced nickel, Japan also imported about 19,000 tons of nickel metal and powder, principally from Canada, the U.S.S.R., Australia, the Philippines, the United States, Zimbabwe, Norway, and six other countries.

Tungsten

Salient tungsten statistics for 1972-81 are shown in table 10. Currently, domestic mine production of tungsten accounts for about 25% of Japanese tungsten consumption. The balance is met by imports of concentrate, ferrotungsten, and metal. In 1981, Japan consumed about 3,200 tons of concentrate for producing ferrotungsten and the metal.

Japan uses tungsten in the form of metal and carbide for the production of ultrahard alloys and for making cutting and wear-resistant materials; about 1,500 tons of tungsten was consumed in these applications in 1981. About 15% of the total tungsten consumption was as ferrotungsten as a steel-alloying element. Domestic mine production of tungsten has decreased annually since 1977, but consumption has increased.

Domestic consumption accounts for the bulk of the total supply of tungsten metal; during 1972-81, slightly less than 12% of total supply (imports plus domestic production) was exported as elemental tungsten. The proportion of ferrotungsten supply used indigenously cannot be pinpointed because ferrotungsten exports are not reported separately.

TABLE 9. - Salient nickel statistics, thousand tons

	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
Imports:										
Ore:										
Australia	81	67	60	[1]33	0	0	0	0	0	0
Canada	39	17	0	0	0	0	0	0	0	0
Indonesia	784	730	792	872	812	878	822	1,128	1,310	1,162
New Calendonia	2,246	2,720	3,363	2,492	2,635	2,680	1,545	2,128	2,000	1,662
Philippines	2	3	3	([2])	3	393	632	759	640	638
Other	0	0	0	([2])	([2])	0	0	0	0	0
Total	3,152	3,539	4,218	3,397	3,450	3,951	2,999	4,015	3,950	3,463
Matte, speiss, other intermediate products:										
Australia	0	7	18	17	28	31	22	24	20	16
Canada	10	19	17	8	13	8	0	([2])	([2])	0
Indonesia	0	0	0	0	0	0	7	10	27	19
Other[3]	3	4	5	2	4	2	1	8	5	2
Total	13	30	40	27	45	41	30	42	52	37
Nickel oxide	0	([2])	0	([2])	([2])	([2])	([2])	1	2	1
Nickel and nickel alloy scrap	2	1	1	2	5	4	4	2	2	2
Nickel ingot:										
Australia	([2])	([2])	([2])	1	2	4	2	3	2	3
Canada	3	5	5	3	1	1	2	5	4	5
Philippines	0	0	0	([2])	1	1	1	1	2	2
U.S.S.R.	4	5	4	2	3	2	2	4	2	3
Other	5	4	7	2	5	3	4	6	5	5
Total	12	14	16	8	12	11	11	19	15	18
Ferronickel:										
Dominican Republic	0	4	5	1	2	4	7	10	9	4
Indonesia	0	0	0	0	6	9	11	11	10	9
New Caledonia	3	5	10	5	0	5	1	9	11	13
United States	1	1	1	1	3	1	1	2	1	([2])
Other	3	2	2	3	3	1	0	1	0	0
Total	7	12	18	10	14	20	20	33	31	26
Estimated nickel content of all imports	85	100	120	90	110	115	95	125	130	110
Processing:										
Ferronickel production (gross weight)	189	200	251	201	198	224	198	304	277	244
Metallic nickel production	16	22	21	13	24	24	22	25	25	24
Nickel content of ferronickel produced	79	88	105	78	95	94	80	101	99	87
Exports:										
Ferronickel:										
Total	19	([2])	2	4	13	2	22	13	17	21
To United States	0	0	2	([2])	([2])	0	17	4	3	15
Nickel, unwrought:										
Total	([2])	([2])	1	1	2	4	3	2	1	1
To United States	0	0	([2])	1	2	1	([2])	1	1	([2])

[1]Includes 25,000 tons credited to New Zealand in source, but almost certainly of Australian origin, plus 8,000 tons credited to Australia.

[2]Less than 1/2 unit.

[3]All from New Caledonia except 3,000 tons in 1979 and less than 500 tons in 1980, from Guatemala.

TABLE 10. - Salient tungsten statistics, tons

	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
Raw material supply:										
Tungsten concentrate production:										
Gross weight........	1,554	1,510	1,398	1,330	1,372	1,315	2,192	2,253	1,894	1,901
Tungsten content....	898	869	810	768	814	772	775	746	667	667
Imports:										
Tungsten concentrate (gross weight):										
Australia.........	119	519	274	221	313	514	221	284	557	336
Bolivia...........	41	69	76	18	18	108	99	194	299	280
Canada............	160	790	386	90	151	347	408	468	675	180
China.............	141	263	288	169	105	178	50	215	165	276
Korea, Republic of	1,220	1,473	1,161	927	855	949	901	815	733	507
Peru..............	397	301	484	212	378	414	290	386	227	137
Portugal..........	0	30	499	144	60	139	79	89	355	468
Thailand..........	283	842	494	186	540	480	175	186	244	48
United States.....	0	0	0	0	127	0	10	380	101	0
Zaire.............	0	130	80	60	30	71	30	20	30	0
Other.............	75	146	76	0	28	47	1	96	94	24
Total.......	2,436	4,563	3,818	2,027	2,605	3,247	2,264	3,133	3,480	2,256
Ferrotungsten (gross weight):										
Austria...........	2	230	2	0	177	138	57	255	51	0
Brazil............	0	20	0	0	0	6	61	158	67	5
China.............	13	0	19	0	147	0	0	10	28	24
Portugal..........	9	157	194	91	163	50	0	60	23	16
Other.............	53	191	16	30	68	15	0	0	17	0
Total........	77	598	231	121	555	209	118	483	186	45
Tungsten metal:[1]										
Austria...........	4	5	11	3	5	5	6	12	11	16
France............	19	47	48	7	4	2	5	3	1	1
Germany, Federal Republic of......	26	73	100	1	1	1	9	7	13	14
Korea, Republic of	([2])	1	1	([2])	85	87	85	112	111	139
United States.....	9	119	172	11	7	13	14	23	16	16
Other.............	2	1	4	([2])	4	4	8	4	6	1
Total........	60	246	336	22	106	112	127	161	158	187
Estimated tungsten content of all imports............	1,700	3,700	3,000	1,400	2,200	2,400	2,700	2,600	2,600	1,700
Processing:										
Production of ferrotungsten........	611	934	276	494	447	371	243	251	242	362
Production of tungsten metal................	1,358	2,018	1,665	885	1,431	1,549	1,479	1,736	2,049	1,820
Exports:[3]										
Tungsten metal:										
Total................	270	96	138	200	190	136	178	265	311	309
To United States....	15	7	25	64	50	33	24	43	61	73

[1]Includes waste, scrap, powder, flake, ingots, and articles of tungsten.
[2]Less than 1/2 unit.
[3]Exports of ferrotungsten are reported with other minor ferroalloys, and thus cannot be reported separately.

STATUS OF THE SPECIALTY STEEL INDUSTRY

PRODUCTION

Production of specialty steel during 1970-81, inclusive, is tabulated in table 1. Production of this steel as a percentage of total steel output has shown an increasing trend. In 1981, Japan produced 13.3 million tons of specialty steel, of which 1.5 million tons was stainless. The configuration of production by type and shape in 1981 are shown in tables 11 and 12.

CONSUMPTION

Much of the specialty steel produced in Japan is used domestically. Compared with the production range of 7.2 million to 13.3 million tons during 1972-81, consumption ranged from 5.3 million to 7.3 million tons during the same period. Consumption by type of specialty steel, totaling 7 million tons in 1981, is shown in table 13. The following tabulation shows total domestic consumption of hot-rolled specialty steel during 1972-81, in thousand tons:

1972....	5,301	1977....	5,900
1973....	6,579	1978....	6,347
1974....	6,136	1979....	6,923
1975....	4,711	1980....	7,278
1976....	5,673	1981....	7,122

TRADE

Japan is an important exporter of specialty steel. Exports for 1973-81 are shown in table 14. The peak export was in 1977 and has gradually declined since then. During this period, it appears that about 15% of total Japanese production of these steels was exported as steel semimanufactures (bars, rods, angles, shapes, sections, plates, sheets, hoops, strips, rails, single-strand wires, pipes, and tubes). Exports as a percentage of production may have an error of plus or minus two percentage points because classification differences do not allow precise comparison between production and exports. The breakdown of these exports in 1981, excluding pipes and ingots, was as follows, in thousand tons:

Type	Quantity
Tool...........................	38.6
Structural.....................	326.4
Stainless and heat-resistant steel.........................	460.7
Other..........................	800.2
Total......................	1,625.9

Specialty steel pipe exports totaled 320,700 tons in 1981, including 64,500 tons of stainless steel pipe and 256,200 tons of other specialty steel pipe. Excluding pipe, the largest export destinations for stainless and other alloy steels in 1981 were the U.S.S.R. (296,000 tons), the United States (283,000 tons), the Republic of Korea (217,000 tons), Taiwan (155,000 tons), India (91,000 tons), and Thailand (75,000 tons).

TABLE 11. - Production of hot-rolled specialty steel, by type, thousand tons

Type	1981
Tool steel:	
Carbon........................	119.2
Alloy.........................	83.5
High-speed....................	15.1
Vacuum........................	4.6
Other.........................	.8
Total.....................	223.2
Structural steel:	
Carbon........................	2,747.3
Alloy.........................	3,296.6
Total.....................	6,043.9
Other specialty steel:	
Stainless:	
Chromium-based............	524.9
Nickel-based..............	1,103.6
Total.....................	1,538.5
Spring........................	621.1
Bearings......................	570.4
Heat-resistant................	45.2
Free-cutting..................	888.3
Wire rods.....................	340.4
High-strength.................	2,958.5
Other.........................	51.4
Total.....................	7,013.8
Grand total...............	13,280.9

TABLE 12. - Production and sales of specialty steel semimanufactures in 1981, thousand tons

	Shapes	Bars	Tubes	Wire rod	Plates	Strips and hoops	Total
Production....	215.4	4,208.6	2,337.0	2,454.5	2,491.8	1,573.6	13,280.9
Sales.........	198.6	3,924.8	0	2,321.3	1,360.4	750.4	8,555.5

TABLE 13. - Consumption of specialty steel in 1981, by type, thousand tons

Commodity	Quantity
Tool steel....................	173.9
Structural steel:	
Carbon and machine...........	2,165.6
Alloy........................	1,308.1
Total..................	3,473.7
Other specialty steel:	
Stainless:	
Chromium-based.............	219.8
Nickel-based...............	447.9
Pipe.......................	48.8
Total..................	716.5
Spring.......................	424.9
Bearings.....................	393.5
Heat-resistant...............	23.6
Free-cutting.................	696.8
Wire rods....................	303.2
High-strength................	454.6
Corrosion-resistant:	
Atmospheric................	176.5
Seawater...................	3.2
Low-temperature..............	81.2
Other........................	18.0
Other alloy pipes............	182.1
Total..................	3,474.1
Grand total............	7,121.7

During 1973-81, inclusive, the United States accounted for 14.7% of all of Japan's exports. However, U.S. imports from Japan have been as high as 45.5% of all U.S. imports and averaged 38.3%. Thus, Japan is more important as a supplier of specialty steel to the United States compared with the U.S. position in Japan's overseas markets.

The variance in the data for Japanese exports to the United States and U.S. imports from Japan for the same period results from classification differences in the respective foreign trade data. Nonetheless, since total Japanese exports and Japanese exports to the United States and total U.S. imports and U.S. imports from Japan are both on comparable bases, the percentages calculated in table 14 are essentially valid.

Trade classification systems of Japan and the United States make it virtually impossible to identify the specific types of alloy steel being traded. In broad terms, about 30% of both the total Japanese specialty steel exports and Japanese specialty steel exports to the United

TABLE 14. - Japanese exports and U.S. imports of specialty steel, 1973-81

Year	Japanese exports			U.S. imports		
	Total, thousand tons	To U.S., thousand tons	U.S. share of total, %	Total, thousand tons	From Japan, thousand tons	Japanese share of total, %
1973..............	1,273	162	12.7	[1]287	[1]113	39.4
1974..............	1,520	184	12.1	[1]285	[1]113	39.6
1975..............	1,258	173	13.8	578	252	43.6
1976..............	1,845	243	13.2	619	260	42.0
1977..............	1,900	331	17.4	716	326	45.5
1978..............	1,884	316	16.8	871	338	38.8
1979..............	1,795	315	17.5	713	257	36.0
1980..............	1,713	198	11.6	656	250	38.1
1981..............	1,702	274	16.1	1,140	350	30.7
Total.........	14,890	2,186	14.7	5,865	2,249	38.3

[1]Partial figure; associated percentages are believed to be reasonably indicative of Japan's share of total.

States over the 1973-81 period can be classified as stainless steel, and the remaining 70% as some other type of alloy steel. On a year-by-year basis, there seems little pattern in the ratio of stainless steel to other alloy steel for total Japanese exports; however, by 1981, the share of the total accounted for by stainless steel was somewhat higher than in any year prior to 1973. A similar year-by-year examination of Japan's exports to the United States seems to show a fairly consistent decline in the percentage of stainless steel composing the total compared with that of alloy steel.

As is noted from the above data, the United States imports a substantial share of its requirements from Japan. Actually, the figures for imports of semifinished forms of specialty steel into the United States from Japan does not show the full picture. Large tonnages of specialty steel are shipped from Japan as components in manufactured materials, but these tonnages generally cannot be statistically separated from other components of the manufactures. One of the exceptions is tableware, where at least a part of the total is identified specifically as stainless steel tableware. During 1972-81, inclusive, Japan exported an annual average of over 20,000 tons of tableware, of which an annual average of 7,300 tons or nearly 37% was shipped to the United States. (See table 15 for annual details.) Similarly, in the case of drill bits, reamers, screw taps, milling cutters, gear cutters and dies, high-speed tool steel can be separated from other steel. For these items, total Japanese exports averaged 2,403,000 tons during 1972-81, of which 218,000 tons (or 9%) was destined for U.S. markets (table 15).

The exports of specialty steel in complex manufactures such as automobiles represent much larger tonnages, but they are not accurately quantifiable. During 1972-81, Japan exported almost 24.9 million completely assembled automobiles, of which over 12.1 million were destined for the United States. On the assumption that each car contains only 100 kg of specialty steel, an annual average shipment of over 120,000 tons of such steel in automobiles to the United States is indicated for the decade. This amount probably understates the actual quantity, but indicates the order of magnitude.

TABLE 15. - Export of selected products containing specialty steel

Commodity	1972	1973	1974	1975	1976
Tableware, stainless steel, tons:					
Total Japanese export	19,397	20,611	21,172	19,972	20,593
Japanese export to United States	7,172	7,277	7,080	7,357	8,129
Drills, bits, reamers, screw taps, milling cutters, gear cutters, dies, tons:					
Total Japanese export	453	492	544	1,189	1,485
Japanese export to United States	94	103	104	144	132
Passenger autos assembled, thousands:					
Total Japanese export	1,313	1,283	1,551	1,594	2,316
Japanese export to United States	638	626	732	739	1,097
	1977	1978	1979	1980	1981
Tableware, stainless steel, tons:					
Total Japanese export	19,601	18,278	18,655	21,161	20,855
Japanese export to United States	6,476	6,551	8,013	7,735	7,569
Drills, bits, reamers, screw taps, milling cutters, gear cutters, dies, tons:					
Total Japanese export	4,431	3,628	3,735	5,247	2,828
Japanese export to United States	183	210	458	442	312
Passenger autos assembled, thousands:					
Total Japanese export	2,778	2,883	3,117	4,027	4,009
Japanese export to United States	1,392	1,521	1,642	1,921	1,841

RAW MATERIALS POLICY

Of all the industrialized resource-poor countries, Japan has undertaken the most comprehensive policy measures to insure availability of raw materials to its economy. To meet domestic demand, Japan actively seeks overseas supplies from as many raw material sources as possible. By securing supplies, Japan protects its large domestic processing sector.

A number of factors, inherent in the Japanese mores and modus operandi, contribute to the successful achievement of the policy objectives:

- Close Government-industry cooperation. The consuming industries consult closely with Government on mineral issues. With intergovernmental agency concurrence, the Ministry of International Trade and Industry (MITI) issues policy guidelines to the industry as needed, as well as provides financial assistance to encourage industry in overseas exploration and investment. This cooperation is not hindered by Japan's antitrust laws, which are not as stringent as those in the United States.

- Worldwide network of contracts through trading companies. The nine major firms (Mitsubishi Corp., Mitsui and Co., C. Itoh Co., Marubeni Corp., Sumitomo Corp., Nissho-Iwai Corp., Toyo-Menka Kaisha, Kanematsu-Gosho, Nishimen Co.) may account for more than half of Japan's trade and as much as 8% of the world's total trade activities. The trading companies and their affiliated metal firms are involved in foreign mineral investment and trade in minerals. These contacts also are helpful in targeting overseas mineral exploration and investment opportunities.

- Bargaining power with producers. Japan has the largest or nearly the largest share of the world import market for many minerals, which contributes to its bargaining power. This bargaining power is increased by the tendency of Japanese firms to enter into negotiation as a group with suppliers.

Substantive policy measures have been in place to (1) generate overseas supplies, and (2) secure raw materials for Japan.

The following measures are employed to generate overseas supplies:

- Promoting overseas exploration. There are regular programs for overseas mineral exploration by the Metal Mining Agency of Japan. These programs provide financial assistance for Japanese mining companies' geological surveys; for Japanese companies' joint exploration with foreign partners; and for overseas exploration.

- Promoting overseas investment. Privated investment in overseas mineral resources is promoted by guaranteeing loans made for such purposes, providing political risk insurance, and supporting mineral projects through aid programs. Mining projects also qualify for Japanese Export-Import Bank assistance. Bilateral aid programs are also coordinated with mineral development interests.

- Offering tax incentives for overseas exploration and development.

- Promoting of research and development through innovative prospecting technology and exploration methods, seabed mineral technology projects, etc.

- Providing technical assistance to suppliers. Joint geological surveys and regional development surveys with developing countries.

Measures to secure overseas supplies.

- Japan relies on the diversification of sources of supply resulting from all the programs cited above, and in securing a concilatory attitude by foreign-policy support for mineral-producing countries.

- In 1976, Japan established three stockpiling programs: nonferrous, light, and "special metals" (which includes nickel, chromium, tungsten, cobalt, and molybdenum). Japan's metals stockpiles stabilize supply from possible short-term disruption in terms of either price or quantity; serve as an economic tool for impacted industries during protracted recessionary times; preserve the terms of ratified contracts that involve long-term deliveries; and, implicitly, enhance the Japanese negotiations for overseas raw materials.

Measures to assist the domestic industry.

- Emergency financial assistance. Metal Mineral Agency of Japan provides guaranteed loans to copper- and zinc-mining companies to insure a stable supply of materials from domestic sources, which provides a fall-back position in extreme situations.

- Promotion of domestic exploration. Government-run wide-area geological surveys of selected districts, subsidies for detailed geological surveys, and support for individual country prospecting.

Although interruption of supply may not be completely ruled out, it seems unlikely that interruption would be total. Perhaps as much as 50% of supply may be denied to the economy. The domestic mining industry and the stockpile would be the only factors to mitigate the unfavorable impact of the supply interruption.

The risk of supply interruption is not the same for all ferroally ores. Relative geographical vicinity to the Philippines, China, India, and Indonesia, and the mineral trade relationship with Australia may continue to offer Japan a measure of supply assurance for minerals produced abundantly in the area.

MEASURES TO ASSURE SUPPLY

STOCKPILE PROGRAMS

Japan has initiated three stockpiling programs, each for a different group of metals. The first stockpiling program was started in 1976, the second in 1982, and the third proposed for 1983. The stockpile objective for each metal inventory in these programs does not exceed a 2-month consumption; in fact, many were for only a 10-day consumption. In this respect, Japan's stockpiling program is different from the U.S. strategic stockpile. Furthermore, industry use of the stockpiles (labeled economic) is not precluded, and in fact, the metals inventory is held by industry.

The first program, started in 1976 and administered by the Nonferrous and Light Metals Stockpile Association, established targets of 9,570 tons of aluminum, 50,370 tons of copper, and 12,050 tons of lead and zinc. At the end of September 1982, metal included in the stockpile was 29,284 tons of aluminum, 1,986 tons of copper, and 73,158 tons of zinc. Changes in the stockpile inventory objective for each metal reflect economic and market conditions. Purchases for the stockpile were made to assist producers when demand was weak. Disposals were made from the stockpile to benefit the consuming sector when demand was strong or in anticipation of a short-term shortage. Other changes resulted from assistance to a distressed industry or for the stabilization of domestic metal prices. This stockpile program is financed by bank loans supervised by the Metal Mining Agency of Japan.

The second stockpile program was for chromium, cobalt, molybdenum, nickel, and tungsten and is administered by the Special Metals Stockpile Association. On November 30, 1982, the following stockpile objectives, equivalent to a 10-day consumption, were established: cobalt metal, 50 tons; ferrochromium, 15,275 tons; molybdenum concentrate, 395 tons; nickel metal, 1,148 tons; ferronickel, 1,620 tons; nickel oxide sinter, 175 tons; and tungsten concentrate, 47 tons. Funds for the stockpile program were being financed by a Government-guaranteed loan from Japanese banks. Purchases for chromium, cobalt, and nickel began in December 1982; purchases for tungsten and molybdenum were expected to begin in January 1983.

Beginning in 1983, the Ministry of Finance was to secure revenue for the purchase of the following 11 metals for a national stockpile proposed by MITI in August 1982: antimony, chromium, cobalt, columbium, manganese, molybdenum, nickel, palladium, strontium, tungsten, and vanadium. The final stockpile objective for each metal--equivalent to a 2-month consumption--was to be attained by 1987 through annual purchases equivalent to a 12-day consumption. In early 1983, the national stockpile program, however, was reduced to seven metals, eliminating antimony, columbium, palladium, and strontium. Purchases for the stockpile, to be conducted by the Special Metals Stockpile Association, are to begin in October 1983. Molybdenum and tungsten are to be stockpiled in the form of concentrate; cobalt and vanadium as metal; nickel as metal, ferronickel, and oxide sinter; and manganese as metal, ferromanganese, and dioxide.

CHROMIUM

Although the Republic of South Africa has been Japan's largest supplier of chromite and ferrochromium (table 6), 58% of the total imports of chromite for 1972-81 has come from non-South African sources. For ferrochrome, South Africa continues to be the dominant supplier. Nonetheless, the diversification of sources for the ore is a positive factor in future supplies.

Since 1970, Japan has made several efforts to achieve the diversification of sources and establish long-term economic or commercial relationships with a variety of major supplying countries, such as the Philippines, Turkey, South Africa, and Brazil. In 1970, Japan reportedly offered financial assistance to Acoje Mining Co. of the Philippines in exchange for increasing its chromium ore exports to Japan. In 1971, the Japan Metals and Chemicals Co. entered into an agreement with Turkey's state-owned Etibank to import 100,000 tons of chromite annually from 1972 to 1981. In return, the Japanese firm offered technology transfer and construction of a ferrochromium plant in Turkey by yearend 1973. In 1971, Japan Heavy Chemical Industry Co. reportedly was helping Johannesburg Consolidated Investment Co. (JCIC) to conduct a survey of chromium ore deposits owned by JCIC in Middleburg-Wietbank in South Africa. In return, the South African organization agreed to export about 300,000 tons of chromium ore and an unspecified amount of pellets to Japan annually over an unspecified period. In 1971, Nippon Heavy Chemical Industry Co. and Showa Denko Co. of Japan had reportedly offered their technical knowledge on processing powdered chromium ore for ferrochromium production to the Brazilian firm Cia. de Ferro Ligas da Bahia, S.A. (Ferbasa). In return, Ferbasa was to guarantee chromium ore shipments to the two Japanese firms for an unspecified long period.

Investment in the Jacobina project in Brazil has been another move by Japan in securing overseas chromium ore and ferrochromium. In 1972, the Brazil Chromium Resources Development Co., a Japanese consortium composed of Japan Metals and Chemicals Co. and six other companies, was formed. Later, a joint-venture firm, Cia. de Mineracao Serra da Jacobina (Serjana), was established by the Brazilian Ferbasa (51%) and the Japanese consortium (49%). Serjana started operation at Campo Formoso in Bahia in 1976, and began shipments of chromite and ferrochromium to Japan in 1977. Since 1972, the Japanese consortium has reportedly invested about $8 million for developing the mine. However, in 1980, Japan withdrew from the joint venture because of the high cost of shipping the ore and a planned reduction in the Japanese ferrochromium capacity.

During 1975-79, a number of Japanese companies were actively involved in joint-venture exploration and development of chromite resources in Madagascar, Sudan, Indonesia, and Papua New Guinea. A brief description and status of these joint-venture projects follow:

Madagascar.--Madagascar Chromium Resources Development Co., a Japanese consortium led by C. Itoh & Co. (and includes Japanese ferrochromium producers) engaged in exploration of deposits in Bemanevika near Andriamena. If developed, most of the chromite output would be exported to Japan. Under a contract signed in 1974, Madagascar began shipments of about 60,000 tons of chromite to Japan annually.

Sudan.--Mitsubishi Corp. and Japan Metals & Chemical Co., Ltd., conducted exploration in the Ingessana Hills area. The deposits were found to be podiform and not consistently of high grade. In 1982, a feasibility study was completed for a $50 million project, which included the construction of a ferrochromium plant and the establishment of a joint-venture mining firm (owned 41% by the Japanese firms). Subsequently, the Japanese proposed a scaled-down project involving a 20,000-ton-per-year ferrochrome plant, but in late 1982 no agreement had been reached. Nonetheless, under a separate agreement, Sudan exported 50,877 tons of chromite to Japan during 1973-76 and an additional 4,500 tons in 1980.

Indonesia.--Japan Sulawesi Chrome Developments, Ltd., a Japanese consortium composed of Kanematsu Gosho, Ltd., Kawatessu Trading Co., and Chuugnai Mining Co., agreed to conduct a $1 million, 2-year exploration for chromium in nickel laterites on Sulawesi Island, an area about 110 miles north of Pare-Pare. If developed, initial output of 200,000 to 400,000 tons of byproduct chromite would be exported to Japan annually. Kawasaki Steel Corp. engaged in a $3 million, 2-year exploration project on the islands of Sulawesi and Halmahera, with the same condition that the chromite would be shipped to Japan.

Papua New Guinea.--Exploration in Salamaua and Salua was to be done by Kawasaki Steel Corp. in a joint venture with AMAX Exploration, Inc., of the United States.

The foregoing illustrate actions taken to diversify sources. Nonetheless, in view of the importance of the Republic of South Africa, a supply interruption from this source and one or two other source countries listed in table 6 would result in a supply decrease of about 50% and, consequently, a substantial reduction in the production of stainless steel, heat-resisting and other alloy steels, and such chrome chemicals as dichromate for tanning. Since new technology allows use of lower grade chromite for the production of ferrochromium, it may be possible to compensate for part of the shortage by increasing imports from the Philippines. Moreover, the potential for development of significant chromite deposits in Indonesia, never before a significant producer, cannot be overlooked, nor can the possiblity of increased acquisition from such sources as Albania, Vietnam, Madagascar, and Iran. Beyond that, availability of stockpile material could only meet a short-term interruption in supply.

COBALT

Zaire is a significant supplier of Japan's cobalt in the form of elemental cobalt and basic cobalt chemicals (virtually all cobalt credited to Belgium originated in Zaire). Over the 1972-81 decade, 80% of Japan's total import of cobalt in the listed chemicals and metal forms was obtained either directly from Zaire or from Zaire through Belgium. In terms of Japan's total supply of cobalt, however, the geographical source pattern change started in 1976, when the country began producing cobalt metal in substantial quantities. The cobalt was recovered chiefly from nickel-cobalt materials obtained mainly from the Philippines and Australia but partly from domestic ores. As a result, cobalt imports from Zaire during 1972-81 represented about 57% of Japan's supply, but in the 5-year period 1977-81, those imports probably did not exceed 33% of supply.

The shift was partly the result of the signing of a long-term contract in 1976 between Sumitomo Metal Mining and the Philippine Marinduque Mining and Industrial Corp. for shipment of nickel sulfide and nickel-cobalt sulfide, presumably from the Nonos Island deposit that had been developed with Japanese financial and technical assistance. The other contributing factor was Nippon Mining Co.'s acquisition of mixed nickel-cobalt sulfides from Greenvale, Australia, under a long-term contract.

Current and near-future dependence on Zaire would diminish if cobalt is increasingly obtained from other producers, most notably Finland and Zambia, both of which are expanding production. Another possibility for reducing dependence on Zaire is the recovery of cobalt from nickel ores now being mined in New Caledonia, Indonesia, and elsewhere. Currently, their processing operations do not recover cobalt separately but leave it as a minor component of the ferronickel produced.

Substitution of other materials for cobalt could reduce dependence on Zaire. For example, high cobalt prices in recent years has resulted in a near-worldwide shift away from cobalt in cutting, wear-resistant, and magnetic alloys. Further, a small share of total annual consumption, estimated at about 1,500 tons, might be provided by additional recovery from complex domestic ores.

In the longer term, Japan's Seabed Mineral Exploration Technology Projects include a series of programs designed to improve exploration methods for deepsea nodules, which contain manganese, nickel, cobalt, and mineral deposits, on the country's continental shelf. The development of such technologies has been designated a "national project."

Despite some diversification of cobalt producers, a long-term interruption in the supply of Zairian cobalt would cause problems for all consumers, including Japan. Presumably to minimize disruption, the Japanese Government has helped to establish and has participated in three stockpiling associations (e.g., the Special Metals Stockpiling Association), which maintain a supply of chromium, cobalt, molybdenum, nickel, and tungsten (including ores and intermediate products).

MANGANESE

In recent years, Japan's domestic resources have not met even a fraction of its total demand for manganese. Consequently, during 1972-81, Japan imported an average of about 1.1 million tons per year to maintain a relatively stable level for manganese in all forms. Domestic mine output over the decade was only 3.2% of total supply, in terms of metal content, and constituted only 2.2% of the 1981 total. In contrast to the situation with chromium, only a small fraction of the need for imports has been met by manganese ferroalloys; average annual imports in this form were only 9,400 tons during 1972-81. Virtually all imports have been as ores: manganiferous iron ores of 15% or less manganese, ferruginous manganese ores that average about 25% to 30% manganese, metallurgical grades of 40% or more manganese, and relatively small quantities of battery-grade ore (dioxide ore) with 50% or more contained manganese. The lower grades of ore (manganiferous iron ore and ferruginous manganese ore) have been obtained almost exclusively from the Republic of South Africa and India, particularly since 1977.

Imports of regular metallurgical-grade manganese ore have been predominantly from the Republic of South Africa (36% of 1972-81 total) and Australia (35% of that total), but the remaining approximately 28% was furnished by nine large suppliers and a number of minor sources. Special dioxide ore, essential for its uses but never a major component of total supply, has been obtained from a variety of countries, with Gabon and Australia being the major sources in recent years. In summary, the Republic of South Africa, Australia, and India have been the principal sources of imports of manganese-bearing ores. In the late 1970's, India restricted exports of high-grade manganese ore but permitted exports of low-grade ore. In the early 1980's, there were labor disputes in Australia. Interruption of supply from either of these countries and the Republic of South Africa would adversely affect the Japanese iron and steel industry. However, Australia and India, because of geographical proximity, will, in all likelihood, continue to be sources. Also, Japan has established trade ties for relatively modest but continuous imports from other major world producers of manganese ore such as Brazil, Gabon, and China, as well as with smaller steady suppliers such as Mexico and Ghana; thus, some diversification of import sources has been achieved. Conceivably, in a crisis, Japan may, as in the past, obtain a modest supply of ore from the U.S.S.R.

Any potential supply shortage could be partially alleviated without major disruption to domestic consumers by reducing ferromanganese exports, which have been equal to 11% of domestic output and 10% of available supply (production plus imports) during 1972-81, inclusive. Nonetheless, it may not be feasible to fill the supply gap resulting from an interruption of ore receipts from the Republic of South Africa.

NICKEL

Japan is a major consumer of nickel but is wholly dependent on foreign sources. Imports include ore, ferronickel, ingot nickel, and a variety of intermediate metallurgical products, such as matte, speiss, nickel-cobalt sulfides, and nickel oxide, from sources shown in table 9. Although some ferronickel is exported, Japan is a net importer of ferronickel.

Nickel ore imports (grading about 1.7% nickel) show no discernible trend; imports of intermediate products and ferronickel have shown a slightly rising trend during the 1972-81 decade, but the variations in the nickel content of all imports generally reflect the ore imports (calculated at 1.5% recoverable nickel), which are the principal raw material for the Japanese industry. Practically all of this ore comes from New Caledonia, Indonesia, and the Philippines; Indonesia and New Caledonia are also the most important suppliers of ferronickel. Since 1974, Australia has been a supplier of nickel intermediate products. In effect, the principal sources are either in neighboring Philippines or the Indian Ocean-South Pacific area, which may be a favorable factor in the continued future supply of nickel to the Japanese economy. Japan and Australia have developed close trade relationships in the mineral area. Japan has provided Australia a natural market for its mineral exports. As a result, the two-way trade between the two countries has grown from $7.5 billion in 1976 to $12.2 billion in 1981. Japan's investment in Australia has also increased. In fiscal 1980, about $431 million (or about 9.2%) of $4.7 billion in direct overseas investment by Japan has been in Australia.

The Japanese involvements in overseas exploration and development of nickel mines were principally in Indonesia and the Philippines, and to a lesser extent, in Australia. The activities involved direct investment in equity, technological assistance, and the so-called loan and sales agreement to secure long-term purchases of output.

Japan's direct investments for the development of nickel mines included the Inco Soroako nickel project in South Sulawesi of Indonesia and the Rio Tuba nickel project on Palawan Island of the Philippines. The Soroako project of Indonesia was developed in the mid-1970's, with a 2.6% equity participation ($11.25 million) by six Japanese companies led by Tokyo Nickel Co. and Shimura Kako Co. The Metal Mining Agency of Japan reportedly provided a $36 million development loan to the project. Rio Tuba project of the Philippines was also developed in the mid-1970's with a 40% equity participation ($881,000). Participation was distributed among the following companies: Pacific Metals Co. (26.8%), Nippon Steel Corp. (5.2%), Nisshin Steel Co. (4%), and Nissho-Iwai Co. (4%) of Japan. The Metal Mining Agency of Japan reportedly provided a $24.2 million development loan to the projects. Most of the nickel in ore or matte produced by these two projects were being exported to Japan.

Japanese technological assistance and about $60 million in loans were reportedly extended by Kobe Steel Ltd., Mitsui Mining and Smelting Co., and other firms to the Nonoc nickel project in Surigao on Nonoc Island of the Philippines. Marinduque Mining and Industrial Corp., the owner and operator of the project, exports annually about 10% of its nickel output and all of its nickel-cobalt mixed sulfides to Japan for further processing.

Nippon Mining Co. and four other Japanese companies signed a loan and sales agreement in 1971 with Metals Exploration Co. of Australia and Freeport Sulphur Co. of the United States for the development of Greenvale nickel project in northeast Australia. Under the agreement, the Japanese were to provide a $30 million loan to the project. In return, the owner and operator of the project was to export about 2,500 tons of nickel oxide and 4,000 tons of nickel-cobalt mixed sulfides annually to Japan for 15 years.

TUNGSTEN

There has been a gradual decline in domestic production of tungsten ore and ferrotungsten (from domestic and imported raw materials), but imports have fluctuated without a discernible trend (table 10). Supply of tungsten in all forms during this decade ranged from a minimum of about 2,170 tons of metal content to a maximum of 4,570 tons, of which 670 to 900 tons was from domestic sources. Imports of concentrates, ferrotungsten, and metal account for about three-fourths of the 10-year supply. Imports of concentrates have come from 25 sources, 10 of which have accounted for the bulk of the total and have been consistent suppliers. The Republic of Korea has been the dominant single source over the decade (31% of the total), and the only significant supplier of tungsten metal since 1976. In contrast, Austria, Brazil, Portugal, and China have been the principal suppliers of ferrotungsten, with no discernible pattern from year to year.

By far the largest share of the tungsten consumption in Japan, as in other industrialized countries, is for the production of ultrahard alloys for cutting tools and wear-resistant materials. Tungsten, as ferrotungsten for making alloy steels, accounts for 15% of total consumption.

As with nickel, a number of significant world producers of tungsten ores, concentrates, and metals are in Southeast Asia and the Far East (Republic of Korea, Thailand, and China); Australia is also an important producer. This favorable geographical distribution of tungsten-producing countries reduces Japan's risk of supply interruption. Domestic production of ferrotungsten has declined, and the compensating increase in imports is largely from Austria, Brazil, and Portugal. In terms of total supply, ferrotungsten imports are not large, and large imports from China could fill a gap. Moreover, considering the relatively small quantity required annually, stockpiling might provide the answer to any short-term interruption of supply.

IMPLICATIONS OF SUPPLY INTERRUPTION

IMPACT ON THE JAPANESE ECONOMY

A simplistic view of the role of the Japanese steel industry in the nation's economy is reflected in its rather small contribution to the gross domestic product (GDP). In 1980, the steel industry, the major component of the basic metals industry, provided the largest part of the 3.8% share of the GDP credited to basic metals (table 16), as well as the largest part of the 1.5% share of GDP credited to fabricated metal products. Similarly, as shown in table 17, the basic iron and steel industry accounts for only 0.8% of the total labor force, and the fabricated metal products industry (including nonferrous metal fabricators) employs only 1.3%.

However, the overall impact of the steel industry on the economy is considerably greater because other industries listed in the GDP summary table and the industrial employment table have steel as an essential input. These industries,

TABLE 16. - Gross domestic product in 1980, by industry

Industry	Gross domestic product, billion yen	Sector contribution, %
Manufacturing:		
Chemicals	5,082.8	2.2
Petroleum and coal products	2,262.7	1.0
Basic metal	8,955.7	3.8
Fabricated metal products	3,477.6	1.5
Industrial machinery	6,354.3	2.7
Electrical machinery, equipment, supplies	8,491.3	3.6
Transport equipment	9,635.8	4.1
Precision instruments	1,462.2	.6
Other	25,356.8	10.8
Total	71,079.2	30.3
Construction	21,480.2	9.1
Other	132,199.5	60.6
Grand total	234,758.9	100.0

TABLE 17. - Employment in 1980, by industry

Industry	Employment, thousands	Proportion, %
Manufacturing:		
Chemicals	409	0.7
Petroleum and coal products	44	.1
Iron and steel	429	.8
Nonferrous metal products	190	.3
Fabricated metal products	745	1.3
Industrial machinery	1,027	1.9
Electrical machinery, equipment, supplies	1,337	2.4
Transportation equipment	887	1.6
Precision machinery	264	.5
Other	4,956	9.0
Total	10,288	18.6
Construction	5,480	9.9
Other	38,592	71.5
Grand total	55,360	100.0

which together account for 30.3% of the GDP and 18.6% of the labor force, depend on steel as an indispensable input and require specialty steel for a substantial part of that input (as in the machine tool industry) or for certain components of the manufacturing process (as in equipment and materials in the chemical or food industry). The diversity of uses of specialty steel within the manufacturing sector in 1980 is shown in table 18.

In addition to its vital role in the manufacturing sector, Japan's specialty steel industry is closely linked to the economic health of the construction industry, which accounts for 9.1% of GNP and 9.9% of total employment. Specialty steel is also essential to numerous other elements of the economy, such as agriculture, forestry, fishing, mining, public utilities, transportation, and communications. As a large exporter of industrial and precision machinery, electric machinery, vehicles, etc., Japan needs to continue producing about 13 million tons per year of specialty steel to maintain its eminent position as a world exporter of finished products.

Japan also is an exporter of other alloy steel. In the 1972-81 decade, these exports ranged from 1.26 million tons to 1.9 million tons. These exports would suffer if production of specialty steel were interrupted or diminished because of inadequate supplies of the necessary ferroalloy raw materials.

IMPACT ON THE U.S. ECONOMY

Japan's overall favorable merchandise trade balance of $8.7 billion for 1981 reversed the annual, negative balances of $7.6 billion in 1979 and $10.7 billion in 1980. Japan's deficit trade results primarily from the cost of crude oil imports from the Middle East. On the other hand, Japan's positive merchandise trade surplus with the United States was $6.0 billion in 1979, $7.0 billion in 1980, and $13.3 billion in 1981. During the mid-seventies, the world energy crisis began to take its toll. Some U.S. industries, including iron and steel, were weakened and began to perform poorly, reflecting depressed domestic and international market conditions, and perhaps poor planning and management. In January 1978, the United States imposed a trigger price mechanism, primarily aimed at Japanese and European steel exports, as a safeguard against the "dumping" of lower priced, imported products.

TABLE 18. - Demand for specialty steel products in 1980, by industry

Industry	Domestic demand, thousand tons	Distribution, %
Automobiles	1,487	20.4
Construction and repairing	441	6.1
Conversion and processing	2,797	38.4
Electric machinery and equipment	73	1.0
Home and office furnishings	199	2.7
Industrial machinery and equipment	1,079	14.8
Rolling stock	35	.5
Shipbuilding and marine equipment	73	1.0
Dealers and traders	845	11.6
Tanks and containers	130	1.8
Other	119	1.7
Total	7,278	100.0

Japan's role as a supplier to the United States of partly processed forms of the commodities covered in this report is not very substantial. Although past Japanese exports to the United States have represented a substantial part of that nation's total exports of ferroalloys, these shipments have been only a modest and diminishing part of total U.S. ferroalloy imports over the 1972-81 decade. Even when the aggregate ferroalloy imports are broken down by alloy type, Japan's contribution to the total U.S. import has never been the largest single element of total U.S. supply. Although it might not be possible to increase domestic output immediately, U.S. production capacity for ferroalloys could easily replace current imports from Japan, assuming that imported supplies of manganese and chromium ores could be obtained. On the other hand, an increase in imports from other foreign producers, chiefly those in Western Europe, the Republic of South Africa, and/or Brazil, could substitute for the relatively small volume of material obtained from Japan.

Japan's exports to the United States comprised less than 15% of total Japanese exports of specialty steel semimanufactures, but comprise over 38% of U.S. imports. However, the share of total U.S. supply was much lower, owing to the relatively high proportion of total supply met by U.S. production. Although alloy steel imports from Japan were more substantial than those of ferroalloys, idle U.S. capacity could easily fill the shortfall, or suppliers in Western Europe could fill a supply gap if Japanese shipments were reduced. It is assumed that the former option could be implemented expeditiously. If neither is exercised promptly, demand for specialty steel for a number of nonessential decorative uses would have to be reduced.

Should the level of manufacturing in Japan suffer because of lack of raw material supply, Japanese export of manufactures would result in reduced exports to the United States and to the rest of the world. Currently, this would spur U.S. output, but limited and reduced supply would increase prices. In the long run, it is possible that products such as U.S.-manufactured Japanese automobiles will increasingly appear on the U.S. market. For consumer durable goods made with specialty steel (e.g., drill bits, cutting tools, and hand tools, and industrial items), the costs to U.S. consumers and users would rise.

CONCLUSIONS

Japan is overwhelmingly dependent on imports of chromium, cobalt, manganese, nickel, and tungsten in various forms such as ores, concentrates, and metal for producing ferroalloys needed in making various types of specialty steel. Interruption of Japan's supply of these raw materials would threaten its immense manufacturing industry, and would also diminish the supply of these materials for countries importing from Japan.

Although the risk in the interruption of supply of the five essential ferroalloy ores and metals cannot be completely eliminated, Japan, among the resource-poor industrialized countries, is better prepared to deal with such a contingency. This results mainly from elaborate and multifaceted policy measures and initiatives, including close Government-industry cooperation, a network of contracts through trading companies, and unique individual business acumen and societal ethics of the country.

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