Chapter 10

Strategies for Future Competitiveness

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The international competitiveness of firms and industries refers to the ability of companies in one country to produce and sell products in rivalry with those abroad. American industries and companies also compete among themselves for markets, profits, and resources such as investment capital and quality employees. How an industry will fare in international competition depends on factors ranging from technology, to governments' industrial policies, to the available natural, human, and financial resources.

Shifts in the international competitiveness of industries affect trade balances, foreign economic policy, and military security, and will determine quite directly the gross domestic product, and therefore the standard of living. The linkage between competitiveness and employment is much looser. By greatly improving their labor productivity, industries can rise in competitiveness while declining in employment.

In practice, the priorities of countries, industries, and firms vary and they use different measures of competitiveness. These, in turn, determine the government policies and industrial management strategies used to maintain or increase an industry's competitive position. Thus, under adverse market conditions, a developing country that uses copper exports to finance imports and economic development may subsidize its copper industry directly. Developed countries tend to use indirect measures such as trade and tax policies to assist industries that are perceived to be disadvantaged due to foreign competition or market conditions.

Analyzing the competitiveness of the domestic copper industry is further compounded by the fact that copper is a fungible commodity. Once established standards have been meant (e.g., the purity of copper to be used for electrical purposes), there is little to distinguish copper produced in the United States from copper produced elsewhere other than its price, including shipping costs.

This chapter discusses the measures of competitiveness that may be applied to the copper industry. It then reviews legislative and industrial strategies that could help to maintain or improve the competitive position of the domestic industry.

MEASURES OF COMPETITIVENESS[1]

No single measure or statistical indicator is adequate to capture the complexity and dynamism of industrial competitiveness. The full panoply of measures might include market share, profitability, cost of production, comparative advantage, ability to attract investment capital, technology and innovative potential, growth rate, capacity utilization, labor productivity, and/or closure costs. Which measures are considered the most important will depend on the firm's ownership and on national and corporate goals and priorities. Where making money is the top priority, then short-term concerns will focus on production costs, profitability, market share, and labor productivity compared to other companies making similar products. If the primary goal is to maintain an industry because its products are important to national security or the economy, then the near-term concerns are more likely to be market share, capacity utilization, and staying power in the marketplace (based on avoidable costs), regardless of profitability. To remain competitive in the long term, however, all industries *must be* concerned about comparative advantage, growth and innovative potential, and the ability to attract investment capital.

[1] Much of the material in this section is drawn from previous OTA reports on industrial competitiveness, including *International Competitiveness in Electronics,* and *U.S. Industrial Competitiveness.* Other sources are referenced as appropriate.

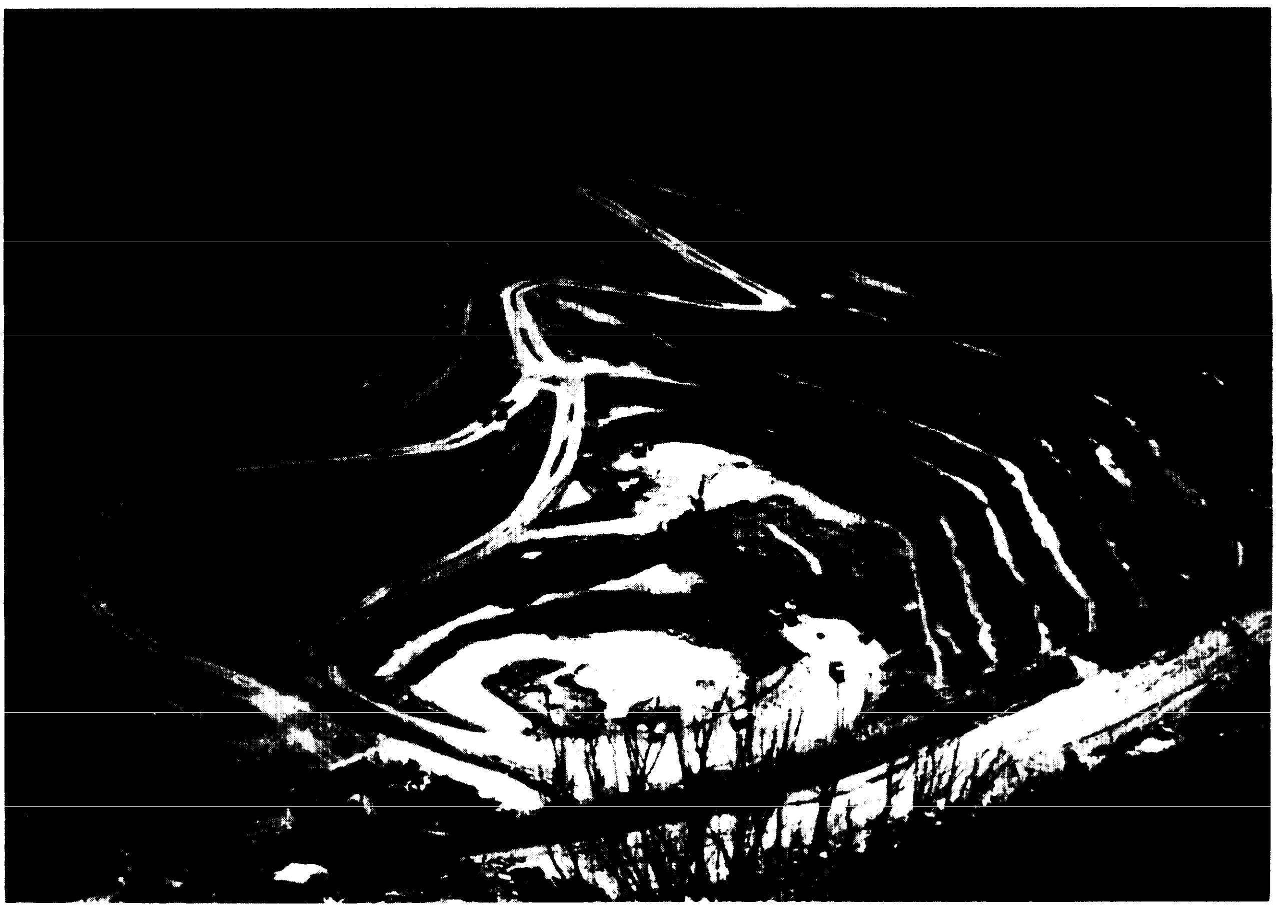
Comparative Advantage

International competitiveness is related to what economists term the global structure of comparative advantage: countries tend to export goods in which they are advantaged and import others. Export earnings are used to finance imports. Nations with the lowest average unit costs are likely to be major exporters.[2] Within this context, however, one must distinguish competition between U.S. firms and those in industrialized countries, versus those in less developed countries (LDCs).

The potential sources of advantage within the world copper industry include resources, labor, capital, markets, and technological capabilities. The domestic industry is both advantaged and disadvantaged in its resource base. On one hand, we have 17 percent of the world's demonstrated resources of recoverable copper—more than any other single country except Chile. Our porphyry ores are suited to large-scale, open-pit mining with relatively low stripping ratios. We also have large oxide deposits, which can be extracted with in situ leaching technology. On the other hand, our sulfide ores are relatively low-grade, which leads to higher production costs due to the expense in handling more material to produce an equivalent amount of copper (see ch. 5).

For porphyry deposits–the majority of world copper resources—this difference in grade will average out over time. For example, ongoing modifications at the Chuquicamata mine/mill in Chile are primarily to accommodate lower ore grades. In 15 years, American mines will still be working approximately the same grade ore they are today, but Chuquicamata's ore grade will have declined more than 50 percent.

[2]Gary L. Guenther, "Industrial Competitiveness: Definitions, Measures, and Key Determinants," Congressional Research Service, Feb. 3, 1986.



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In newly-industrializing economies, workers often are available in large numbers at low wage rates. This can provide a production cost advantage. The trade-off for industrialized economies is high labor productivity. Domestic copper labor productivity is excellent, and has improved markedly during the 1980s (see ch. 3). Wage reductions in 1986 plus continuing productivity gains have improved our cost competitive situation, but labor is still a much higher percentage of the U.S. production cost than for most foreign competitors (see ch. 9).

Large markets allowing economies of scale in production and lower transportation costs can be a source of comparative advantage. in the copper industry, however, this is largely negated by the extensive international trade. Moreover, as the less developed countries (LDCs) become more industrialized, their domestic markets for copper will expand.

Access to investment capital is another potential source of comparative advantage. Nongovernmental firms in industrialized countries typically raise capital through loans or sales of equity shares (stock). Cross-subsidization also can occur within a firm to the extent that profits from one product or division can be used to help another division over temporary hard times; this is one advantage of diversification. Government-owned copper operations rely more heavily on debt financing, often through international banking organizations (e. g., the Multinational Development Banks). As LDC debt multiplies, however, such loans will become more difficult to obtain (see ch. 3).

Finally, technological capabilities can be a source of comparative advantage. These include the employee skills as well as research and development (R&D) investments. While the United States has some advantage over less industrialized countries in this area, this often is negated by the speed of technology transfer (see below).

Although comparative advantage theory is a useful starting point for understanding the resource economics of international competitiveness, it overlooks other important trends. For example, shifting trade patterns are inevitable as third world countries become more developed. Yet it is difficult for mature markets to accommodate both established domestic producers and the development objectives of new market entrants, or to make the transition for domestic companies less painful. Economically, the problem is ascertaining the net gains from trade (e.g., to fabricators and consumers) after deducting adjustment costs for producers. Politically, the problem becomes one of determining how these net benefits shall be distributed both within a single economy and between it and its trading partners. j

An additional question is whether government policy, over time, can influence comparative resource advantages. Such policies might include worker training, funding for R&D related to unique resource endowments, or facilitating access to capital (e.g., through tax incentives).

Market Share

International competitiveness defined in terms of market share is the definition given at the beginning of this chapter—the ability of firms in one country to design, develop, manufacture, and market their products in rivalry with firms and industries in other countries. **Market share may refer to a country's portion of total world production or shipments, it may mean net exports (value of exports less imports), or it may describe the fraction of the domestic market that is met by domestic production.** A major shortcoming of this measure is that losses in market share for heavily industrialized countries are inevitable as other nations progress economically.

American copper companies dominated the world market until the late 1960s. Then came a wave of nationalizations in Latin America and Africa. Where foreign governments did not completely take over, they exerted greater influence on operating patterns. Government ownership and control of foreign operations meant not only a loss of assets, but also a loss of market power. American companies no longer could regulate foreign production during times of reduced demand. Companies that lost foreign properties also were no longer able to use low-cost overseas pro-

[3]John Zysman and Laura Tyson (eds.), *American Industry in International Competition: Government Policies and Corporate Strategies* (Ithaca, NY: Cornell University Press, 1983).

duction to offset curtailed output at higher-cost domestic mines when prices were lowa

Table 10-1 compares U.S. market share in 1981 and 1986. **Our share of world mine production declined 6 percentage points from 1981 to 1986, and the share of primary smelter output and refinery production dropped 8 points and 3 points, respectively. In contrast, U.S. copper demand as a percent of Western world consumption remained constant. The difference between production and consumption shows clearly in the increase in U.S. net import reliance from** 6 **percent in 1981 to 27 percent in 1986. It** should be noted, however, that the period 1981-1986 was extraordinary. 1980 and 1981 were years of record consumption and production; they were followed by the recessionary conditions of 1982-**84** and a gradual recovery thereafter. The recovery is expected to continue for mining; the U.S. Bureau of Mines projects 1988 domestic mine production at around 1.45 million tonnes–only 6 percent lower than in 1981.[5]

4"U. S. Industry Responds to Dramatic Changes in World Role, " *CRU Copper Studies, vol. 14, No. 4,* Oct. 1986.

Table 10-1 .—U.S. Market Share in the Copper Industry: 1981.86 (1,000 metric tonnes)

	1981		1986		
Measure	Tons	% of total	Tons	% of total	% change
Mine production:					
United States	.1,538	23%	1,147	17%	–25%
World[a]. . .	.6,489	100	6,629	100	2
Primary smelter production:					
United States	,1,317	21	908	13	–31
World[a]	.6,059	100	6,828	100	12
Primary refinery production:					
United States	,1,227	19	1,073	16	–13
World[a].	6,327	100	6,348	100	<1
Refined consumption:					
United States ., ..	.2,030	27	2,122	27	5
World[a] ..	.7,252	100	7,672	100	6
U.S. imports for consumption:					
Ore and concentrate	39		4		–89
Refined	331	16[c]	502	24	51
Unmanufactured[d]	438		598		36
U.S. exports:					
Ore and concentrate	151		174		15
Refined	24		12		–50
Unmanufactured[d]	NA		442		
U.S. net import reliance (%)	·6		27		350

aMarket economy countries
'Copper content.
cPercent of U.S. refined consumption.
dIncludes coppe, content of alloy scrap.
eAs a percent of apparent consumption; defined as imports - exports + adjustments for Government and industry stock changes.
SOURCE: OTA from Bureau of Mines and World Bureau of Metal Statistics data,

Although the United States has become a net importer of refined products, we continue to be a net exporter of copper concentrates. Domestic mine capacity utilization is relatively high for those mines considered to be economic properties in the current market (81 percent for mines operating in 1986). It is unlikely that the domestic industry could supply a much larger share of the market without reopening mines that have been closed for most of this decade or developing new capacity.

Smelter output dropped so much during this period due more to the permanent closure of facilities for environmental reasons than to economic conditions. Further major declines in domestic smelter capacity are unlikely (unless stricter emissions limitations are imposed), although smelter production is likely to fluctuate with market conditions. Indeed, domestic smelter capacity may increase with the addition of one new smelter, but it probably will be built by a Japanese firm. Thus it will contribute to domestic market share and employment, but not the market share or income of U.S. firms (unless they supply the concentrates).

The fraction of domestic consumption accounted for by imports reflects domestic versus foreign production costs (see below), as well as government policies (e. g., export subsidies), corporate strategies (closing mines, foregoing markets), and other factors. Export subsidies by LDCs are likely to continue. If the relative growth rates in U.S. and world copper consumption over the last 15 years continue over the next 15, with slow growth in U.S. mine capacity but more rapid growth in solvent extraction/electrowinning, U.S. refined production will continue to be about half of domestic consumption.

[5]Personal communication to OTA from Daniel Edelstein, U.S. Bureau of Mines.

Cost of Production

Market share is only indirectly related to the competitiveness of individual firms, which are more likely to be concerned with production costs, Gross costs are determined by wage rates and labor productivity; the cost of materials, equipment, transportation, and energy; and the design of both products and manufacturing processes. Net costs also account for byproduct credits.

Generalizations about production costs are possible, but tend to be disproved by site-specific factors. For labor-intensive technologies such as underground mining with conventional smelting, developing countries with an abundance of inexpensive labor normally would be expected to be the low-cost producers. Yet Canada, with around 75 percent of its output from underground mines, has high gross costs but low net costs because of their advantageous byproduct credits, Moreover, despite the advantage gained from abundant human resources, developing countries still can benefit from technologies that are not labor intensive if they offer low capital costs and ease of operation (see discussion of technology transfer, below).

In 1986, estimated average net operating costs in the United States were 54 cents/lb. The average producer price for that year was 66 cents/lb. **Worldwide, the average net operating cost for the top 12 producing countries was around 44 cents/lb.** The range of costs in 1986 was estimated to be as low as 26 cents/lb and 30 cents/lb for Papua New Guinea/Indonesia and Chile, and as high as 70 cents/lb in the Philippines (see ch. 9).[6]

The United States is most competitive in refining, with average costs comparable to those of the rest of the world. Because refining is only around 7-8 percent of the total cost of production, however, it provides little leverage in overall competitiveness. Domestic mining and milling costs were high, averaging 75 percent of the operating cost, primarily because of low domestic ore grades with only moderate byproduct credits and high labor costs.

Although smelting accounts for only 17 percent of domestic operating costs, **the United States had the highest smelting costs of all the major producing countries in 1986** due to labor costs and the additional cost of acid production for environmental control (currently around 87 percent sulfur dioxide removal). Adding an acid plant to the production line increases operating costs without necessarily providing a byproduct credit. Furthermore, capital costs of acid plant construction are high. Copper smelters in Canada, Chile, Mexico, Peru, Zaire, and Zambia–our major foreign competitors—are not faced with similar environmental regulations (see below). T

Profitability

The profitability of an operation or firm is its real net income. **Profitability is largely determined by the difference between the cost of production and the price at which the product is sold.** Other factors can affect profitability, however. For instance, in Mexico, copper is traded in U.S. dollars, but profits are measured in pesos. Shifts in the exchange rate affect the amount of profit at a given price. In recent years, exchange rates in market economy countries have been free to adjust to prevailing market conditions. One consequence of more flexible exchange rates is that domestic industries may be competitive at one time but not another solely because of exchange rate shifts.

For a nongovernmental corporation, profitability directly determines whether a company or facility will continue to operate, and for how long. Profitability controls the ability to obtain debt and to attract equity investors. it also determines the amount of money available for maintenance and capital improvements. Government-owned operations in developing countries are concerned more with generating foreign exchange than with

[6]Janice L. W. Jolly and Daniel Edelstein, "copper," preprint 'rem 1986 *Bureau of Mines Minerals Yearbook* (Washington, DC: U.S. Department of the Interior, 1987).

[7]Lawrence J. McDonnell, "Government Mandated Costs: The Regulatory Burden of Environmental, Health, and Safety Standards of U.S. Metals Production, " paper prepared for the conference Public Policy and the Competitiveness of the U.S. and Canadian Metals Production, Golden, CO, January 1987.

profitability, and can sustain operating losses for a longer period.

Domestic copper companies lost a lot of money during the depressed conditions of the early 1980s. Amoco Minerals lost nearly $60 million on copper from 1981 to 1985, when they spun off their copper properties to Cyprus Minerals; Phelps Dodge lost **$400** million between 1982 and 1984; and Kennecott lost over $600 million between 1982 and 1985. Anaconda–for decades the giant of the world mineral industry—went out of business. This situation began to change in 1985, and has continued to improve since, as costs declined while demand and prices increased. **All the major domestic companies except Magma had a positive net income in 1987, and Magma expects to be profitable when their smelter furnace replacement is complete.**

Technology

The definitions of competitiveness discussed above are based on either market or resource economics. Other definitions are technology-based, and refer to superior product and process technology. The types of definitions are not necessarily unrelated—superior process technology is one way to achieve low costs; superior products are one way to increase market share.

The role of technology is less important in determining competitiveness in the copper industry than in, say, electronics, for two reasons. First, technology transfer among companies and countries is rapid. Second, copper is a fungible commodity with well-established standards for purity, so distinguishing among companies' products is difficult.

Technology transfer is the interchange of technological innovations among companies and countries. When one company or country develops a new process that either reduces costs, improves productivity, or exploits new resources, it enjoys a competitive advantage as long as the innovation remains secret or is protected by patents. The innovation is then transferred to other countries or companies through licenses under the patent, and the licensee pays royalties. Over time, incremental changes remove even patent protection, and the innovation is adopted universally where it can bestow some benefit. This process may occur quickly, or it may take years.

In the copper industry, technology transfer is almost instantaneous. This occurs for several reasons. First, most major technological advances in copper mining and processing are developed and introduced by equipment vendors rather than copper producers. The vendors have a financial interest in seeing rapid and widespread adoption of their innovations. The value of this trade by domestic vendors is important for our balance of payments. Exports accounted for around 33 percent of U.S. mining and mineral processing machinery shipments in 1982, while imports were only 7 percent of domestic consumption. While other countries are beginning to make inroads on world market share in mining and processing machinery, the United States remains a net exporter in this area. B

In contrast, modern smelting furnaces and the latest advances in electrowinning (the Mt. Isa process) were developed in other countries. Yet American copper producers also benefit economically from the productivity gains and cost reductions brought by foreign technological advances.

Other innovations are adapted from other metals sectors. For example, the earliest concentration techniques were developed based on methods used on gold ore. The solvent extraction/electrowinning (SX/EW) process originated with uranium processing. Moreover, because each ore body is unique, copper companies typically need to engineer an innovation to suit their own situation. These multiple, incremental changes largely negate the purposes of patents.

Finally, porphyry ore bodies–which have been the focus of copper exploration and development for much of this century–are very similar all over the world. Their similarities have helped to standardize mining and metallurgical strategies for their exploitation, and thus facilitate rapid technology transfer.

81 International Trade Administration (ITA), A *Competitive Assessment of the U.S. Mining Machinery Industry* (Washington, DC: U.S. Government Printing Office, 1986).

In searching for a competitive advantage through technological innovations, therefore, domestic companies need to emphasize either technologies that are unattractive to developing countries or that apply to a limited range of resource conditions. Developing countries are attracted to technologies that: 1) require minimal capital, 2) can be built quickly, 3) can be amortized rapidly, 4) have low operating costs (including low energy consumption), and 5) require minimal technical skills and supervision.[9] This implies, for instance, that developing countries with resources suited to SX/EW processing will favor this technology over pyrometallurgical methods, because relatively simple mixers and settlers replace grinding mills, classifiers, flotation cells, smelters, and all their controls, and recyclable organic solutions supplant grinding media and flotation reagents. More importantly, SX/EW is very flexible in its applications and can be run practically at any scale, which makes it very convenient for application in developing countries. It's few environmental control requirements also may become increasingly important outside the United States.

Although SX/EW is a technology that transfers easily, domestic copper companies still may gain from its use in situations not applicable in other countries. For example, while all porphyry ore bodies tend to have oxidized caps suitable for SX/EW methods, the United States maybe unique in having a large resource of previously uncataloged oxide ore bodies (apart from the porphyry caps) particularly amenable to SX/EW treatment. Such oxide ore bodies are one resource that could provide a domestic competitive advantage relatively immune to subversion through technology transfer in the short-term. Small-scale SX/EW plants also are very attractive for leaching old, "worked-out" mines and waste dumps, also prevalent throughout the Western United States.

New domestic operations in the near future are more likely to exploit smaller, relatively high-grade (e.g., 3 percent) deposits, while overseas operations that wish to capitalize on foreign exchange will prefer large ore bodies. The technology transfer advantages here depend on the type of operation and the goal of copper production. For in situ leaching, this may confer an advantage on U.S. greenfield operations, which will emphasize small deposits until the technology is proven.

For sulfide ores, foreign and domestic operations will remain dependent on pyrometallurgical processing in the near-term. While the United States has a clear advantage here in the productivity of their operations, this is largely negated by lower foreign labor costs and the difference in environmental control requirements. Any imposition of air quality control regulations in foreign countries would benefit domestic companies in several ways, including a "leveling of the playing field" on environmental control costs, their advantage in acid plant operating experience, and the ability to market control technology.

The rapidity of technology transfer in the copper industry does not mean that we should stop investing in innovation. I n the period before an innovation becomes standardized, its developer enjoys a competitive advantage. In addition to direct investments, a variety of other policies–such as tax policies on capital income, depreciation policies, and policies to support R&D—may influence the pace of technological change and hence competitive advantage.

Staying Power[10]

A final measure of competitiveness is termed staying power: the ability to survive in the marketplace over the long-term despite short-term losses of cash or market share. Staying power stems from low current operating costs and/or high exit barriers, including perceived and actual costs of closure.[11] A high-cost mine that also has high closure costs or operators willing to subsidize losses exhibits greater staying power. Its persistence in a depressed market also may exert

[9]United Nations Industrial Development Organization (UNIDO), *Technological Alternatives for Copper, Lead, Zinc and Tin in Developing Countries,* report prepared for the First Consultation on the Non-ferrous Metals Industry, Budapest, Hungary, July 1987.

[10]Barbara J, Evans, "How To Assess the Staying Power of World Copper Mines," *Engineering & Mining Journal,* April 1986.

[11]closure costs at 10 large open-pit copper mines in the Western United States that closed between 1981 and 1983 were between $0.20/lb and $0.22/lb of lost copper production during a 12-month closure period.

downward pressure on the price to a level that forces competitors with less staying power to close. Thus it is more the staying power of competitors than their profitability that affects a company's relative outlook.

Competitive rankings based solely on cost of production distort the relationship between competitive strength and profitability. Competitive strength is the ability to maintain a position in the market. This ability is a prerequisite, but not a guarantee of profitability. Competitive strength and profitability depend on different cost considerations. The former is a function of operating cost and price, while the latter depends not only on earnings, but also on exit barriers. Only when operating earnings drop below the cost of withdrawing from the market does a facility stand to lose its staying power.

Comparing staying power in governmental operations is more difficult. Closing a State-owned mine is touchy—it creates unemployment and degrades foreign exchange. Operating losses can be sustained so long as mineral sales generate enough foreign currency to cover the foreign-currency portion of operating costs. But many State-owned mines that operated throughout the recent recession did not have to be subsidized because they are strong, low-cost competitors. In other cases, subsidization was a sound business decision to endure operating losses to avoid even greater direct closure costs. To determine the staying power of operations with persistent subsidization, overall closure costs can be set equal to the country's debt capacity, as a worst-case measure, As noted previously, debt will become a more important consideration for future capital investments at copper operations in LDCs.

FEDERAL POLICIES AFFECTING COMPETITIVENESS

Federal policy toward an industry can be expressed in legislation, executive orders, treaties, rulings of commissions, government participation in international organizations, etc. There is no comprehensive national industrial policy, let alone a national minerals policy. Depending on the philosophy of individual administrations, measures directly related to competitiveness (such as trade relief) often meet with little success. Similarly, the policies with the most far--reaching impacts on the competitiveness of the U.S. copper industry may have been instituted for reasons totally unrelated to copper markets (e.g., environmental regulation).

Current Federal policies with potential impacts on the competitiveness of the domestic copper industry include those related to taxation, trade, defense, the environment, R&D, industrial development in general, and foreign aid. This section reviews all of these policy areas except foreign aid, which is discussed in ch. 3.

The effects of these policies on the U.S. copper industry vary. Decisions under various trade initiatives generally have gone against the industry. When coupled with U.S. contributions to international loans that contributed to gluts in the copper market, trade and foreign policy have had significant adverse impacts on competitiveness. On the other hand, government denial of trade relief during the 1980s forced the copper industry to pull itself up by its own bootstraps—in part through investments in new technology and increased productivity. These efforts are discussed in the following section.

Environmental regulation also has been very costly to the industry (although beneficial to society as a whole). Even here, however, the primary impacts (smelter closure or the capital cost of new smelters) have run their course. Barring any further changes in environmental control requirements, the remaining burden is in slightly higher operating costs compared to countries without similar environmental controls.

Other policy measures, such as tax policy, can be very beneficial, depending on a company's capital structure and investments. Still others, e.g., defense policy and the present modest Federal investments in R&D and industrial incentives related to education and training, are neutral or provide small benefits.

Federal Tax Policy

Governments have long used tax provisions to further objectives such as raising revenues, promoting economic development, and conserving resources. For capital intensive industries like mining, the tax regime can make or break a particular project. Thus, **taxation relative to that of other producing nations is an important element in the domestic copper industry's competitive position.**

The major copper producing countries have different tax regimes, which include income taxes as well as sales, social security, capital, and severance taxes, and royalties. In the United States, Canada, and Australia, copper companies also are subject to State or Provincial taxation. Of all these taxes, national income taxes probably are the most critical in determining an industry's international competitiveness. Moreover, income taxes are the favored tax route for providing benefits to a specific industrial sector. The effects of specific tax provisions on an industry also can vary widely over time depending on economic variables such as the price of the goods produced, the age of capital investments in plant and equipment, inflation rates, etc.

A 1986 study (i.e., before the Tax Reform Act of 1986) of the structure of international mineral income tax systems found the U.S. tax regime very competitive.[12] Based on a hypothetical 20-year copper/gold mine in British Columbia, that study examined the top marginal income tax rates, capital cost recovery, investment-related incentives (e.g., investment tax credits, depletion deductions) and other deductions, and the resulting tax base as a percentage of discounted operating cashflow for 8 major copper producing countries.[13] In addition, the study discussed the sensitivity of effective tax rates to changes in profitability, inflation rates, and product price cycles.[14] Although the U.S. minerals industry had the second highest marginal tax rate, they had the second lowest income tax base, primarily due to generous investment incentives and other deductions (see table 10-2),

According to the Congressional Budget Office (CBO), **before tax reform the U.S. mining industry benefited more than any other sector from preferences that reduced its taxes.**[15] The two most important tax provisions targeted specifically at the mining industry are depletion allowances and expensing of exploration and development costs, both continued under the 1986 Act. Other pre-1 986 tax benefits applicable to all industries included the accelerated cost-recovery system (ACRS) and the investment tax credit.

The depletion allowance enables mineral producers to deduct a percentage of taxable net income based on either investment cost or a specified fraction of gross sales from the minerals extracted, whichever is higher. In recent years, the depletion allowance has been limited to 50 percent of taxable net income. In theory, Congress intended this allowance to stimulate exploration and thus provide for the replacement of depleted mineral properties. In effect, a mineral property usually is so long lived that the company is able to write off its original investment several times over. CBO estimated the excess of percentage depletion over cost recovery for non-fuel minerals to be $300 million in FY 1984.[16] Because the allowance is tied to revenues, it will vary depending on the health of the industry, however.

The minerals industry also may deduct a maximum of 70 percent of the cost of exploration and development in the year incurred, and capitalize the remaining 30 percent over a 5-year straight-

[12] Keith Brewer et al, "Fiscal Systems, " paper presented at the Conference on Public Policy and the International Competitiveness of North American Metal Mining, Golden, CO, January 1987.

[13] Australia, Canada, Chile, Peru, Papua New Guinea, South Africa, United States, and Zambia.

[14] The United States was not included in the sensitivity analyses for profitability and inflation, but our pre-reform tax regime was similar to Canada's and the results should be comparable.

[15] U.S. Congress, Congressional Budget Office, *Federal Support of U.S. Business* (Washington, DC: U.S. Government Printing Office), January 1984.

16Ibid. see also pa u I R. Thomas et a 1., The Depletion Allowance *and Domestic Minerals Availability: A Case Study in Copper* (Washington, DC, U.S. Bureau of Mines, Information Circular 8874), 1982.

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Table 10.2.—Mineral Income Tax Comparisons

Country	Top marginal rate	Capital cost recovery	Total deductions and investment incentives	Tax base[a]	Base case	Profitability: Low (5% IRR)	Profitability: High (23% IRR)	Inflation: 5%	Inflation: Cyclical prices
Australia[b]	49.0%	51.0%	73.0%	27.2%	100	333	77	104	105
Canada[c]	45.3	50.7	74.7	25.3	100	144	120	127	97
Chile	40.0	53.0	56.7	40.6	100	174	93	113	102
Peru	57.0	52.0	64.0	35.5	100	178	97	110	97
PNG[d]	35.0	48,0	48.0	52.0	100	211	85	113	102
South Africa	46.2	53.0	60.5	37.3	100	128	100	114	98
United States[e]	54.2	48.5	76.5	23.5	100	NA	NA	NA	91[f]
Zambia	45.0	53.0	15.5	16.5	100	0	175	175	75

[a]As a percent of operating cashflow; calculations based on a 15 pre-tax IRR mining project over a period of 20 years. Cashflows and tax bases are discounted at 5%.
[b]Based on Queensland.
[c]Arithmetic average of results of Quebec, Ontario, Manitoba, and British Columbia. Only Federal and provincial income taxes are considered,
dPNG tax system has a top marginal rate of 70% which is triggered only at a very high profitability level.
eArithmetic average for States of Utah and Alaska, only Federal and State taxes are considered. Based on tax code before tax reform of 1986.
‘For Alaska only.

SOURCE” Keith Brewer et al. “Fiscal Systems, ” paper presented at the Conference on Public Policy and the International Competitiveness of North American Metal Mining, Golden, CO, January 1987.

line depreciation schedule.[17] This defers a portion of income taxes until the deductions have been taken. For development expenditures, only the amount that exceeds the net receipts of the mine for a given year may be included, CBO estimated that expensing and depreciation under the old 80/20 formula amounted to $60 million for the non-fuel minerals industries in FY 1984.[18] The minerals industry notes that other industries receive similar benefits through tax credits for research and deductions for new product development.

While the Tax Reform Act of 1986 reduced the top corporate tax rate from 46 percent to 34 percent, it also set the minimum tax at 20 percent and significantly reduced investment incentives and other deductions. In addition, the 1986 law limited the use of foreign tax credits, repealed ACRS and the investment tax credit, and changed the depreciation schedule for mining equipment from 5 years at 150 percent to 7 years at 200 percent. The percentage depletion allowance and expensing of exploration and development costs were retained.

With the possible exception of effects on financing foreign operations, U.S. minerals companies do not view the new tax regime as bringing major changes for them. Their current focus on restructuring and modernization, rather than expansion, does not raise any immediate concerns about the tax changes. Those expansions that are planned are primarily solvent extraction and electrowinning facilities, with a low capital cost compared to smelters. Smelting and refining are capital intensive, and new facilities will be less attractive under the new tax system. Companies face so many other problems with a new smelter (such as environmental costs), however, that it is unlikely that taxation would be the deciding factor, Mining is more oriented toward labor and equipment costs than capital investment and may gain a slight tax advantage.[19]

Instead, **it is the conditions the** U.S. **economy and its minerals industry might face in the next 5 to 10 years that may raise questions about tax policy.** The lower top tax rate benefits profitable projects more than marginal ones.[20] While this rewards success, and thus sends appropriate market signals, it also can significantly reduce government revenues, and budget pressures may lead to a rate increase once again.

Accelerated depreciation allowances minimize the effect of cyclical prices on effective tax rates.

[17] These are the allowances under the Tax Reform Act of 1986. Previously, industry was allowed 80 percent expensing, with 20 percent capitalizing.
[18] CBO, supra note 15.

[19] John J. Schanz, Jr. and Karen L Hendrixson, ‘‘Impact of Existing Federal Policies on the Copper Industry, ” Congressional Research Service report prepared at the request of the Subcommittee on Oversight and Investigations of the Committee on Energy and Commerce, U.S. House of Representatives, July 1986.
20 Brewer et al, supra note 12.

Firms are able to claim greater amounts of depreciation during periods of higher profits. The capital cost recovery system for the U.S. minerals industry did not change significantly, so the industry's taxes should remain relatively sensitive to cyclical prices. A switch toward more rigid depreciation schedules similar to the accounting treatment of capital costs would result in higher effective tax rates for mining. This change was discussed extensively in the debate over the Tax Reform Act of 1986, but was not included in the final package.[21]

The repealed investment incentives and deductions also are less valuable to the more profitable projects. The investment tax credit primarily provided inflation protection for capital intensive ventures. During periods of low inflation, this fixed investment incentive can result in very low effective tax rates. Thus, while its removal should increase government revenues over the short term, it also makes the current tax regime relatively insensitive to inflation. A return of high inflation rates could lead to heavy industry pressure to reinstate the credit or other investment incentives. [22] Incentives also could be used to encourage investment in heavy industry and new technology to increase productivity in the event of a recession.

pressure to raise revenues in order to decrease the U.S. budget deficit may lead to higher tax rates for industry i n the short term. Obvious targets would include increasing the maximum tax rate, and adjusting the depletion allowance and expensing of exploration and development costs, which represent the greatest amount of foregone revenues from the minerals industry.

A final aspect of tax policy that might be considered affects copper consumers. If the conditions that occurred during the early 1980s–lower-cost imports taking over an increasing share of the domestic market and a significant decline in U.S. copper production—were to recur, tax incentives could be used to stimulate the purchase of domestic copper. Thus, consumers who paid more for U.S. copper might be subsidized through a tax deduction or credit tied to the difference in cost between foreign and domestic copper.

[21] Ibid.

22Ibid

Trade Policy

International trade and financing activities in the copper industry have been highly contentious in recent years. **The U.S. industry has been severely critical of some foreign operations' refusal to curtail production in light of the oversupply conditions existing in the world market. Domestic producers have sought to curb these foreign activities through legislation, appeals to the International Trade Commission, and other political and legal means, but have been largely unsuccessful.**

Because global copper trading, pricing, and financing are highly developed and integrated, few market activities have single, isolated effects.23 Instead actions in one part of the market are quickly felt throughout the world. The high level of U.S. imports subjects domestic producers to constant competitive pressures from the world market. [24] During the past decade, as imports gained an increasing share of the domestic market, the U.S. copper industry requested on several occasions that the Federal government relieve the foreign pressure through a variety of trade measures. Some of the requests claimed that the domestic industry needed trade relief in order to restructure and modernize. Others complained that differing business environments in the United States and abroad result in advantages for foreign producers.[25] A few charged that foreign activities violate international trading codes (such as the General Agreement on Tariffs and Trade, GATT) and their counterparts in U.S. law.

Section 201 Cases

The most publicized copper industry complaints were the Section 201 cases filed in 1978

[23] The copper market is characterized by high levels of trade (in 1985, trade accounted for 23, 11, and 40 percent of NSW production of ores and concentrates, blister, and refined copper, respectively), a very mature world pricing system, and a high level of international Investment (see ch, 3),

24The United States is the world largest importer of refined copper. In 1986, U.S. imports totaled 502,000 tonnes of refined copper, accounting for almost a quarter of consumption (see ch. 4).

[25] The catch phrase used in this argument is that an "uneven playing field" exists in the copper industry.

and 1984. Sec. 201 of the Trade Act of 1974 (also called the Escape Clause) is designed to provide temporary import relief to domestic producers seriously injured by increased import competition.[26] The relief is to be used for economic adjustment programs, such as restructuring and modernization. The fairness of trading practices (e.g., dumping or subsidization) is not at issue in Sec. 201 cases; those matters are handled in antidumping and countervailing duty cases (see below).

Sec. 201 requires that an industry convince both the International Trade Commission **(ITC)** and the President that it merits trade relief. First, the ITC determines whether imports have caused the domestic industry serious injury, and if so, recommends trade actions to prevent or remedy the injury.[27] The remedies that the **ITC may recommend** are limited to tariffs, quotas, tariff-rate quotas, and trade adjustment assistance for workers. If the ITC finds serious injury, the President must review the case, and either provide import relief or determine that doing so is not in the national economic interest. Whereas the ITC's determination centers on imports and the health of the domestic industry, the President's decision is based on a broader concept of economic interest that also includes the well being of workers and consumers and strategic concerns. If the President decides that relief is appropriate, it can take the form of the ITC's recommendations; a different package of tariffs, quotas, and tariff-rate quotas; or negotiation of orderly marketing agreements (bilateral agreements to restrict imports into the United States).

26A concise description of Section 201 as well as other aspects of U.S. trade law appears in, U.S. House of Representatives Committee on Ways and Means, Subcommittee on Trade, Overview of Current Provisions of U.S. Trade Law, USGPO WMPC:98-40 (Washington, DC: 1984).

27The ITC must "determine whether an article is being imported into the United States in such increased quantities as to be a substantial cause of serious injury, or the threat thereof, to the domestic industry producing an article like or directly competitive with the imported article. " Substantial cause is defined as "a cause which is important and not less than any other cause. " If the ITC makes an affirmative injury determination, it must (1) find the amount of the increase in, or imposition of, any duty or other import restriction which is necessary to prevent or remedy the injury, or (2) if it finds that adjustment assistance can effectively remedy the injury, recommend the provision of such assistance.

In 1978 and again in 1984, the ITC found that rising imports were causing serious injury to the domestic copper industry and recommended that the president remedy the injury.[28] In both instances, the president denied import relief because it was deemed not in the national economic interest. In the 1984 case, the ITC's findings were sent to the President 2 months before the presidential election. Such timing is usually a political advantage for the domestic industry because of the voting power and campaign contributions of those who may benefit from trade relief. Despite this pressure, President Reagan ruled that import relief was not in the national economic interest due to the potential damage to copper fabricators (which have more employees than the mining and processing industry), and the inconsistency of such relief with the President's free trade philosophy. The existence of the Carbon Steel Sec. 201 case, on which the President had to decide shortly thereafter, was probably an additional reason for denying help. If the copper industry were granted trade relief, the steel industry would have merited equally generous measures.

Although trade relief was denied in the 201 cases, the proceedings' publicity yielded some secondary benefits. The attention brought to the industry's plight by the 1984 case probably helped producers negotiate wage and benefit concessions from labor unions and rate decreases from electric utilities. The cases also highlighted the problem of access to markets. Some foreign companies' production strategies are now more likely to consider the impact on U.S. competitors in order to avoid conflicts.[29]

Unfair Trading Cases (Antidumping and Countervailing Duty)

Antidumping cases allege selling prices of less than fair value. Countervailing duty cases claim subsidization. These tend to be narrower in scope and usually are publicized less than Sec. 201

[28]Both cases covered unwrought, unalloyed refined copper. The 1984 case also covered black copper, blister copper, and anode copper.

[29]Jose Luis Mardones and Isabel Marshall, "Lobbying by ExPorters: The 1984 Copper Import Case, " paper presented at the Copper 87 Conference, Vina del Mar, Chile, Nov. 30 to Dec. 3, 1987.

cases. The fabricated copper products industry has filed several of these unfair trading cases. In 1986, the **ITC** and the Commerce Department found that the brass sheet and strip producers were being injured by imports from Brazil, Canada, South Korea, France, Italy, Sweden, and West Germany that either were subsidized or sold at less than fair value (i. e., dumped).

Copper Trade Legislation

Because of the industry's troubles, copper trade has been the subject of a number of bills considered by Congress in the early 1980s. The proposed legislation has dealt primarily with the oversupply situation in the copper market. An example is the Trade Act of 1984, which contained a nonbinding clause stating that the U.S. government should negotiate with foreign copper producers for lower copper production in order to raise the price. President Reagan denied this request, citing the infeasibility of negotiating the required agreements (Chile in particular showed signs of being uncooperative); potential antitrust violations in getting the required cooperation among U.S. producers; and the negative effects of increased costs for consumers. Congress included a binding version of this clause as an amendment to the Textile and Apparel Trade Enforcement Act of 1985, but that bill was vetoed by the President.

Another example is the Minerals and Materials Fair Competition Act of 1987 (S. 1042), which has yet to be reported out of the Senate Finance Committee. This legislation would amend many U.S. trade statutes to recognize subsidized excess foreign capacity as a source of injury to producers of nonagricultural fungible goods (including copper).[30] In addition, the Act would establish that a principal U.S. negotiating objective within GATT would bean agreement imposing sanctions against providing subsidies for excess capacity. Furthermore, the bill instructs U.S. representatives to the International Monetary Fund (IMF) to ask for a ban on loans or other financing assistance from the Compensatory Financing Facility (CFF) to countries that do not agree to adjust production and to refrain from adding further capacity. In the absence of an overall IMF ban, the U.S. representatives are to vote against all CFF loans to countries that do not agree to adjustments.

An excess capacity subsidy provision also was included in the Senate version of the Omnibus Trade and Competitiveness Act of 1987. The provision classified as an unreasonable trade practice foreign subsidization of industries that produce non-agricultural goods for which worldwide production exceeds demand. This provision did not make it into the conference report that was passed by both houses of Congress in 1988.

In 1984 and 1985, Congress also considered bills to increase the duty on imported copper in an amount that would offset the cost to the domestic industry of complying with environmental regulations. In 1984, legislation was passed that suggested that copper be given higher priority within the stockpile, and added a ' 'Buy America" clause to the stockpile.

U.S.-Canada Free Trade Agreement

The United States and Canada signed an accord in January 1988 that seeks to liberalize trade and investment between the two countries. This bilateral agreement would eliminate all tariffs on goods trade by 1998, reduce nontariff trade barriers, establish rules for bilateral investment, and create a dispute settlement mechanism.[31] To be enacted, the U.S.-Canada Free Trade Agreement (FTA) must be approved by the U.S. Congress and the Canadian Parliament.

The FTA is opposed by several major copper producers, represented by the Non-Ferrous Metals Producers Committee (NFMPC),[32] primarily **because it fails to prohibit some Canadian subsidization practices.** They are concerned that

30 Ma, or statutes that would be amended by the Minerals and Materials Fair Competition Act of 1987 Include Section 301, Section 201, and antidumping and countervailing duty provisions,

31 The accord also deals with services trade, business travel, energy and national security concerns, and some outstanding trade issues.

32 The Non-Ferrous Metals Producers Committee (NFMPC) is a trade association whose members are Asarco, Phelps Dodge and the Doe Run Co. (a lead producer based in St. Louis, MO). Their position on the FTA is outlined in the statement by Robert J. Muth, President, before the Mining and Natural Resources Subcommittee of the Interior and Insular Affairs Committee of the U.S. House of Representatives, March 10, 1988. In addition to subsidies, the NFMPC is against the FTA because it weakens judicial review in unfair trade cases and eliminates the tariff on imports of Canadian copper.

Canadian copper companies are using below-market-rate capital from various national and provincial government assistance programs to modernize facilities. As an example, the NFMPC cites the C$83 million loan from a government acid rain program for modernization and pollution control at Noranda's copper smelter at Rouyn, Quebec. Noranda does not have *to re*-pay the loan through monetary reimbursement; it may substitute "additional investments aimed at maintaining its commitment to Quebec's copper industry."[33] There also have been suggestions that subsidies may be made available to reopen Noranda's Gaspe copper mine in Murdockville, Quebec (closed in April 1987 because of a fire), and to the Hudson Bay Mining and Smelting Co. copper smelter at Flin Flon, Manitoba. **These subsidies are especially disturbing to the U.S. producers because half of the increase in copper imports since 1985 came from Canada.** Moreover, even after modernization, Canadian smelters will control less than half as much sulfur dioxide as U.S. smelters.

The FTA does not actually sanction the subsidization programs, but leaves their legality to be resolved by a bilateral working group established to iron out the differences between U.S. and Canadian unfair trade law. Until the group finishes its work (up to 7 years), both countries would apply their own antidumping and countervailing duty laws to any disputes that may arise. For cases under these laws that are investigated during this interim period, the FTA comes into play at the end of the proceedings, after the ITC and the Commerce Department (or their Canadian counterparts) have made their final determinations. Independent binational panels would review contested determinations for their consistency with the laws of the country that made them; national courts currently undertake such review .34

Miscellaneous Domestic Trade Developments

The Generalized System of Preferences (GSP) program allows certain products to be imported duty-free into the United States from LDCs to promote their economic development. In December 1987, Chile's benefits under the GSP program were rescinded because it was determined that Chile consistently denies its workers basic labor rights. [35] This, however, does not cover a great deal of copper trade because blister, anode, and refined copper from Chile were already excluded from the GSP program.

Miscellaneous International Trade Developments

In 1984, **the European Economic Community** (EEC) complained to the GATT Council that Japanese tariffs were pushing European companies out of the copper ore and concentrates markets. Japanese tariffs are high for refined copper, but low for concentrates (see discussion of trade in ch. 4). The EEC claimed that this tariff schedule allowed Japanese copper smelting and refining firms to consistently pay higher prices for concentrates than European firms could afford, thus assuring raw material supplies for themselves to the detriment of European competitors.[36] Some domestic copper producers also had protested the Japanese practices to the U.S. government since their inception in the late 1960s and early 1970s, but without avail.

In 1984, a working group was created within GATT to study international trade problems affecting nonferrous metals and minerals. The group is to identify measures taken by importing and exporting countries that hamper world trade, and make recommendations on how trade might be liberalized.

Since 1985, the United States has been working with other copper producing countries to

33"Copper," *Metals Week, vol. 59, No. 20,* May 16, 1988.

34 In the United States, an unfair trade case can be concluded once the ITC and the Commerce Department have made their findings. Quite often, however, the determinations of these agencies are challenged before the U.S. Court of International Trade.

35Under authority of the Generalized System of preferences Renewal Act of 1984.

36Janice L.W. Jolly and Dan Edelstein, "Copper, " 1984 *Minerals Yearbook, Volurne /,* (Washington, DC: U.S. Department of the Interior, Bureau of Mines, 1986).

establish a Producer/Consumer Forum patterned after the International Lead Zinc Study Group. This organization will compile copper statistics, develop quantitative information on existing capacities and end-uses, and provide a forum for discussions about the problems and opportunities of the copper industry. [37] It will play only a minimal role in market development activities such as advertising and promotion. The Forum will be autonomous rather than meet under the auspices of United Nations Conference on Trade and Development (UNCTAD).[38]

Intergovernmental Council of Copper Exporting Countries (CIPEC)

Most of the major world copper producing countries (Chile, Peru, Zambia, Zaire, Indonesia, Australia, Papua New Guinea, and Yugoslavia) belong to the Intergovernmental Council of Copper Exporting Countries (CIPEC). Established in 1967, this trade association conducts marketing studies, disseminates information on copper developments, and seeks to promote expansion in the industry. During 1974-76, in the wake of OPEC's success in raising oil prices, CIPEC attempted to establish itself as a cartel. It tried, but failed, to stabilize then falling copper prices through production cutbacks. The group has discussed price stabilization numerous other times but has been unable to agree on a program, and CIPEC's power to manage supply and stabilize markets has never been established.

Defense Policies

Copper is a strategic material—one that is essential in the production of equipment critical to the U.S. economy and the national defense. In 1986, the United States imported around 27 percent of its refined copper consumption. This is more than the total amount used by the electrical and electronics industry in 1986. The principal sources of imports were Chile (40 percent), Canada (29 percent), Peru (8 percent), Zambia (7 percent), and Zaire (6 percent).[39]

While neither political instability nor hostility is a major concern about the security of supplies from these countries, their imports can be subject to disruption. For example, one of the most disruptive interruptions in U.S. materials supply in the last 30 years was the loss of nickel from Canada during the 4-month labor strike against the Canadian nickel industry in 1969. At that time, Canada supplied 90 percent of U.S. primary nickel supplies.[40] A similar occurrence in Canada's copper industry would cut off U.S. imports equivalent to the amount used for consumer goods, military applications, and chemicals in 1986.

Moreover, **supplies do not actually have to be interrupted to have significant economic impacts on U.S. mineral markets.** A rebel invasion of Zaire's mining country in 1978 led to fears of a cobalt shortage that stimulated panic buying. Prices went through the roof, and domestic users turned to cheaper substitutes and recycling where possible. However, mining and processing facilities were closed only briefly, and cobalt production in Zaire and Zambia actually increased 43 percent in 1978 and 12 percent in 1979.[41] The transportation routes from the mining districts in Zaire and Zambia are considered very insecure because the rail lines pass through Angola, Mozambique, or South Africa.

Potential supply interruptions of imported copper are not considered as critical as those for metals such as chromium and cobalt, which are not produced in the United States and do not have readily available substitutes. The economic consequences of a supply shortfall could be severe for U.S. industry, however. The price of copper and its substitutes would increase dramatically. It would take anywhere from 6 months to sev-

[37] Janice L.W. Jolly, "Copper," 1985 *Minerals Yearbook, Volume I*, (Washington, DC: U.S. Department of the Interior, Bureau of Mines, 1987).

[38] Creation of the group was first proposed at an ad hoc meeting convened by UNCTAD to review copper market conditions

[39] Janice L. W. Jolly and Daniel Edelstein, "Copper, *Mineral Commodity Summaries: 1987* (Washington, DC: U.S. Department of the Interior, Bureau of Mines) 1987.

[40] U.S. Congress Office of Technology Assessment, *Strategic Materials: Technologies To Reduce U.S. Import Vulnerability* (Washington, DC: U.S. Government Printing Office, OTA-ITE-248) May 1985.

[41] Ibid.

eral years to bring U.S. idle mine capacity and unexploited reserves into full production. Companies would not be willing to incur the capital investment to do so without assurances that production would continue for long enough to recoup the investment. Moreover, most imports are in the form of refined and unmanufactured copper. Replacing these would require either drastic increases in SX-EW capacity, or the reopening of currently idle smelter capacity (and thus substantial capital investment in new furnaces and pollution control), or a massive recycling effort.

The United States has long had legislative policies designed to provide either supplies of copper or additional productive capacity in the event of a supply interruption that threatens national security. This legislation includes the Strategic and Critical Materials Stock Piling Act of 1946 and the Defense Production Act of 1950.

The National Defense Stockpile

Congress first authorized stockpiling of critical materials for national security in 1939. World War II precluded the accumulation of stocks, and it was not until the Korean War that materials stockpiling began in earnest. Since then, U.S. stockpile policy has been erratic and subject to periodic, lively debate over the amount of each commodity to be retained and over the disposal of stockpiled items for budgetary reasons.

Stockpile goals are currently based on having a 3-year supply of materials needed to meet national defense and industrial needs in a defense emergency.[42] A transaction fund dedicates revenue from Federal sales of stockpile excesses to the purchase of materials short of stockpile goals.[43] In 1986, the total stockpile inventory was valued at approximately $10 billion. If the stockpile had met all goals, it would have been valued at about $16,6 billion in 1986.[44]

[42] The number of years supply needed is set according to the anticipated duration of a hypothetical emergency, not according to the leadtime needed to replace foreign supplies with domestic sources.

[43] Strategic and Critical Materials Stock Piling Act of 1979, Public Law 96-41, 50 U.S.C. 98 et seq.

[44] Federal Emergency Management Agency, *Stockpile Report to the Congress: October 1985-March 1986*, FEMA36, 1986.

Copper is a strategic commodity in the National Defense Stockpile. The current goal is 1 million short tons, with a 1986 inventory of 22,297 tons of copper, plus 6,751 tons of copper contained in 9,645 tons of brass.[45]

Over the years stockpile acquisitions and releases have affected copper supply and price. In 1954, market shortages due to a labor strike led to the release of 40,000 tons. From 1959 to 1963, stockpile acquisitions combined with copper labor strikes and strong economic expansion to push prices upward.[46] The most significant releases–550,000 tons–occurred in 1965-66 under a declaration of national emergency due to the Vietnam War. These releases occurred at a time of growing demand, disturbances affecting overseas production, and rising domestic prices. Consumers welcomed the resultant downward pressure on prices, but others alleged that the stockpile was being used as an economic buffer rather than for defense. Q'

In the early 197os, the overall stockpile objectives were reduced to a 1 -year supply, and the copper target was reduced to zero. Virtually all of the copper remaining in the stockpile was sold during the commodity price boom of 1974. In 1979, Congress reinstated the 3-year planning period for defense emergencies, and the copper goal was set at 1 million tons,

Most recently, legislation was introduced in the 98th Congress (1 983-84) to purchase copper for the National Defense Stockpile to prod the sluggish markets, Opponents argued that the acquisitions would have been insufficient to reopen any shutdown operations, and would have established a precedent of allowing economic considerations to supersede defense needs.

Bringing the stockpile up to its goal of 1 million tons would require the purchase of almost 971,000 **tons of copper. This is equivalent to 90 percent of 1986 U.S. primary refinery production, and 13 percent of Western world production.** Even if spread over several years, such purchases would exert significant upward pressure

[45] Ibid.

[46] U.S. Department of the Interior, Bureau of Mines, *Minerals Yearbook,* varlous years,

[47] Schanz and Hendrixson, supra note 19.

on copper prices during periods of low demand or excess supply. While this could help the U.S. industry weather a market slump, it also could send false market signals to foreign producers, and encourage overbuilding of capacity.

The Defense Production Act

The Defense Production Act of 1950 (DPA) provides several mechanisms for assuring availability of materials and industrial capacity needed for national security. Title I authorizes the setting of government priorities for materials allocation in a national emergency or war. Title III provides loans or loan guarantees for corporate activities that would expedite production in the event of a national emergency. These include expansion of capacity, development of technological processes, or the production of essential materials, including exploration, development and mining of strategic metals. **Under DPA, the government also may purchase metals and minerals for government use or resale.**

In the 1984 **reauthorization of DPA, Congress established new procedures** for authorization of Title ill projects in the absence of a national emergency or war.[48] The law requires the President to determine that Federally-supported projects meet essential defense needs and that the Federal support offered would be the most "cost-effective, expedient, and practical alternatives for meeting the need." Industrial resource shortfalls for which Title III assistance is sought must be identified in the budget submitted to Congress.

Numerous DPA contracts and agreements were established between 1951 and 1956, when copper was in short supply. These involved government loans, direct purchases, subsidies of otherwise uneconomical output, and accelerated amortization for income tax purposes. Between 1951 and 1958, the Defense Minerals Exploration Administration offered loans of up to 50 percent government participation for copper exploration. In 1967, when copper was again in short supply, the Duval Company's Sierrita mine received a $56 million loan. **The DPA has not been used to support the domestic copper industry since 1969, when the last copper exploration participation contract expired.**[49]

Although DPA provisions generally have been used to encourage mining of strategic minerals, the law also could be used to ensure adequate smelting and refining capacity to meet domestic national security needs, and to develop advanced technologies considered desirable for enhancing the security of domestic resources.

Environmental Regulation

The copper industry is subject to numerous Federal and State regulatory requirements related to environmental protection and worker health and safety. These range from the preparation of an environmental impact assessment prior to initiating a mining project, to the control of air and water pollution during mining and processing, to the reclamation of tailing piles and dumps when an operation closes. Throughout, operations are scrutinized by the Mine Safety and Health Administration and the Occupational Health and Safety Administration. Other types of legislation either regulate the location of mines on public lands or withdraw those lands from mining altogether.

This section briefly reviews the major Federal programs and discusses their effects on competitiveness; the pollutants of concern and technologies for their control are described in chapter 8. It is important to note that individual States also may have relevant legislation (especially related to groundwater protection) that imposes additional standards and permitting, inspection, and enforcement requirements.

The National Environmental Policy Act

The National Environmental Policy Act of 1969 (NEPA) requires, for "major Federal actions significantly affecting the quality of the human environment" (e.g., leasing Federal land for mining), that an agency prepare a statement that describes possible environmental impacts, any adverse effects that cannot be avoided (including irreversible commitments of resources), and alternatives to the proposed action and their impacts,

48Public Law 98-265,

49Schanz and Hendrixson, Supra note 19.

New copper mines are opened infrequently in the United States, and copper companies rarely have to go through the NEPA process. When they do, however, it can be time consuming and expensive to provide all of the data needed by the agency preparing the environmental impact statement (EIS). Moreover, because of the extensive public participation in the NEPA process, it is often the largest source of delay in any new venture that comes under its aegis.

The Clean Air Act

The Clean Air Act sets standards for both ambient concentrations of pollutants and emissions from individual sources. The National Ambient Air Quality Standards (NAAQS), which address ambient concentrations, include primary standards designed to protect human health and secondary standards to safeguard public welfare. The Environmental Protection Agency (EPA) has set primary and secondary standards for sulfur oxides, particulate matter, nitrogen dioxide, hydrocarbons, photochemical oxidants, carbon monoxide, ozone, and lead.

Every major new source of emissions (e.g., a new smelter furnace) is required to undergo a preconstruction review to ensure it will not violate NAAQS. Sources in dirty-air areas, or at the opposite extreme, those where the air is already much cleaner than the standards require, are subject to more stringent permitting requirements for new sources. In addition, operating sources are required to use technological controls to meet emission limitations, which set quantitative limits on the amount of pollutants that can be released to the atmosphere.

At copper operations, the primary concerns are sulfur dioxide (SO_2), particulate, and fugitive emissions from smelting and converting; and fugitive dust from tailings piles and waste dumps (see ch. **8). At most smelters, meeting the emission limitations has meant completely changing smelting technology, including installing a new furnace, collecting the various gas streams, and treating them,** first in an electrostatic precipitator to remove the particulate, and then in an acid plant to convert the sulfur dioxide to sulfuric acid. The acid plant adds significantly to operating costs. The sulfuric acid may be salable and provide a byproduct credit, but at most operations it is a red ink item. **While the furnace types that are amenable to sulfur dioxide control are more efficient than the old reverberatory furnaces, the gain in efficiency is offset by the capital and operating costs of control.** One copper company estimates the capital cost of modifying its smelter for pollution control at $154 million, with a net gain of perhaps 1 cent/lb lower operating costs.

The Clean Water Act

The Clean Water Act establishes water quality standards that focus on the uses of the waters involved, including public water supplies, fish and wildlife, recreation, and agriculture. The standards generally are achieved through effluent limitations that restrict the quantities, rates, and concentrations of chemical, physical, biological, and other types of discharges from individual sources. In general, the Act requires all categories of sources (including copper mines, mills, smelters, and refineries) to apply the best practicable control technology currently available in order to meet the effluent limitations.

Effluent limitations and water quality standards are implemented through State certification programs and through the National Pollutant Discharge Elimination System (NPDES). All point sources must obtain State certification that their operations will not violate any effluent limitations, water quality standards, or new source performance standards. They also must obtain a NPDES permit, which requires a demonstration that the discharge will meet all applicable water quality requirements. NPDES permits are issued under EPA-approved State programs.

Effluent limitations for copper mines, mills, and leach operations cover discharges of copper, zinc, lead, and cadmium, as well as total suspended solids and pH. Arsenic and nickel are not specifically mentioned in the standards because they are adequately controlled by the removal of other metals found in the discharges. Leaching operations generally are expected to achieve zero discharge unless the annual precipitation exceeds annual evaporation (rare in the arid and semi-arid copper-producing areas of the Western United States). Guidelines are being developed for effluents discharged from primary copper smelters, copper refineries, and acid plants. These limitations aim to control the amount of arsenic, cadmium, copper, lead, zinc, and nickel in effluents; the pH of the discharge; and the concentration of total suspended solids.

Safe Drinking Water Act

Congress enacted the Safe Drinking Water Act in 1974 to ensure that water from public drinking supplies is healthful.[50] Primary standards, or maximum contaminant levels (MCLs), are set based on the contaminant concentrations at which no known or anticipated adverse effects on human health occur, modified by the best available treatment technology (considering cost). Secondary standards set goals for contaminants that primarily affect the aesthetic qualities of drinking water.

The Safe Drinking Water Act also protects sole source aquifers, or those aquifers that supply 50 percent or more of the drinking water for an area, from contamination due to projects above the aquifer. It requires States to establish "well head protection areas" around public wells to prevent pollutants from entering underground supplies. EPA has designated the groundwater systems of the Upper Santa Cruz Basin and the Avra-Altar Basin of copper-producing Pima, Pinal, and Santa Cruz counties in Arizona as a sole source aquifer.[51]

Resource Conservation and Recovery Act

The EPA regulates hazardous and other solid wastes under the Resource Conservation and Recovery Act (RCRA). Subtitle C of RCRA establishes regulations for the generation, transportation, treatment, storage, and disposal of materials identified by EPA as hazardous. Subtitle D provides Federal guidelines for EPA-approved State or Regional solid waste plans. These address the regulation of landfills, dumps, and ponds handling non-hazardous solid and liquid wastes. Box 8-C in chapter 8 discusses the EPA decision that solid wastes from the mining and beneficiation of copper ores should be regulated under Subtitle D of RCRA as non-hazardous solid waste. The rationale for this decision was that the large volumes of mine waste would be very difficult to regulate under rules that had been designed to manage much smaller amounts of hazardous industrial and municipal waste. EPA also reasoned that Subtitle C does not allow considerations of environmental necessity, technological feasibility, and economic practicality, which are important given the magnitude of mine waste, The cost of mine waste management under Subtitle C of RCRA would result in closures at domestic mines and mills with very large amounts of waste material.

Comprehensive Environmental Response, Compensation and Liability Act (Superfund)

Superfund allows the EPA to respond to actual or threatened leaks from inactive hazardous waste treatment, storage, and disposal facilities, and to notify the public of such releases. It also provides the authority and framework for cleanup of orphaned hazardous waste sites. Although mining wastes are exempt from RCRA Subtitle C regulation, EPA has made it clear that such materials are not exempt from Superfund. The EPA's policy on the continuing availability of the mining waste exclusion for inactive or closed facilities will affect the extent to which Superfund liabilities and obligations may arise from the closure

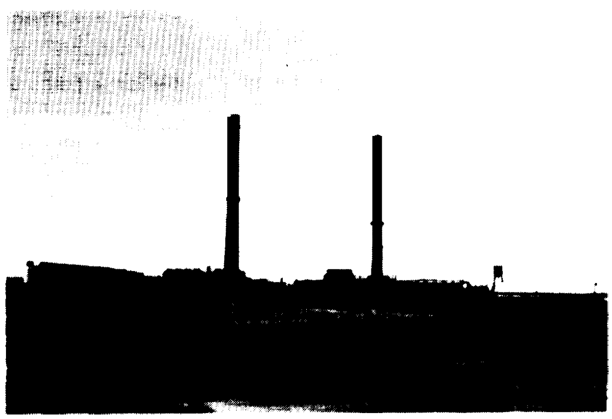

Photo credit' Vickie Basinger Boesch

The Douglas, Arizona smelter, which was built in 1904, closed permanently in 1987 because it would have been too costly to rebuild to bring into compliance with air quality standards.

[50] 'Public" supplies are those drinking water systems serving 25 or more people, or 15 service connections.

[51] Donald V. Feliciano, "Sole Source Aquifers and Related Congressional Districts, " Congressional Research Service, March 1984.

of a facility .52 Therefore, when considering closure, the potential application of immediate or future hazardous waste regulatory scrutiny must be evaluated.

Worker Health and Safety

Mining activities come under the aegis of the Federal Mine Safety and Health Act of 1977, which regulates on the theory that a safe mine is a productive mine. The Act sets mandatory standards and requires training for new employees plus annual refresher training for all mine workers. The Occupational Safety and Health Act, which covers mills, smelters, and refineries, is similar.

Other Federal Legislation

In addition to the specific requirements of the Federal and State laws discussed above, a wide range of other laws affect the operations of the domestic copper industry. These are listed in table **10-3.** They fall into two main categories: laws that regulate mining activities on public lands, and laws that withdraw public lands from mining. A third group comes into play only when special circumstances arise, such as finding archaeological relics on a mine site, or having protected species located on or near a facility.

'*Lester Sotsky, "Closing of a Facility–Legal Concerns, " paper presented at American Mining Congress, Annual Mining Convention, San Francisco, CA, 1985.

Effects of Environmental Regulation on Competitiveness

In general, the more developed a country is, the more detailed and comprehensive are its environmental controls. In developing countries, any environmental regulation usually is the result of negotiated agreement between the host country and the would-be investor. Increasingly, mining agreements now include various provisions regarding environmental protection. **Although there seems to be a trend toward more stringent environmental controls in LDCs, their**

Table 10-3.—Other Federal Legislation Affecting Copper Operations

Public lands	Withdrawals	Other
Act of September 28, 1976: Provides for the regulation of exploration and mining within, and repeals the application of mining laws to, the National Park System	**Wilderness Act of 1964: Provides for** establishment of wilderness reserves; requires preservation of wilderness areas in an unimpaired condition	**Antiquities Act of 1906: Regulates** antiquities excavation and collection, including fossil remains
Forest and Rangeland Resources Planning **Act of 1974: Provides for a comprehensive system of land and resource management planning for National Forest System lands**	**Wild and Scenic Rivers Act:** Provides for preservation of certain rivers or portions thereof in their natural state	**Archaeological and Historical Preservation Act of 1974: Provides for recovery of data from areas to be affected by Federal actions**
Multiple Use-Sustained Yield Act of 1960: Requires management of National Forests under principles of multiple use so as to produce a sustained yield of products and services	National Trails System Act: Provides for establishment and protection of trails	**Bald Eagle Protection Act of 1969: Protects bald and golden eagles**
National Forests Management Act of 1976: Provides for a comprehensive system of land and resource management planning for National Forest System lands		**Endangered Species Act of 1973: Protects endangered and threatened** species and critical habitats affected by Federal actions
Federal Land Policy and Management Act of 1976: Provides for comprehensive, multidisciplinary land use plans for Bureau of Land Management lands, including multiple use of lands and resources and protection of areas of critical environmental concern		

SOURCE: Office of Technology Assessment, 1988.

impact on mining is considerably less than in developed countries such as the United States.[53]

With the exception of air quality control, few data are available on the costs of meeting all environmental and health and safety requirements in the United States. Even fewer data are available on the extent to which foreign operations protect public and worker health and safety or the costs of doing so.

Such regulation in the United States has brought enormous—but unquantifiable—benefits, from fewer fatal mining accidents, to fewer premature deaths due to air pollution, to cleaner lakes and streams. The costs to the U.S. industry also have been large, with substantial negative impacts on competitiveness and capacity.

In 1970, when the Clean Air Act first imposed emission limitations on smelters, EPA estimated the total cost of compliance in the entire nonferrous industry at $45 million. This grossly underestimated the capital cost of acid plants. Because technological means of control were not yet mandatory, most smelters used supplemental and intermittent SO_2 controls[54] instead, which avoided the large capital costs but reduced production. When technological controls were imposed in 1977, EPA estimated that, if all smelters were assumed to progress toward full compliance by 1988, the total capital cost would be $1.9 billion for the period 1974-87, with total operating costs of $1.1 billion (1974 dollars). If, on the other hand, 3 smelters (Douglas, McGill, and Tacoma) were assumed to close in 1983, the EPA estimates of total capital and operating costs for 1974-87 declined slightly to $1.7 billion and $1.05 billion, respectively (1974 dollars).[55]

In reality, the primary copper industry had capital investments totalling $2.1 billion for air pollution control between 1970 and 1981 (in 1981 dollars), with total annual costs of $3.1 billion over the same period. Estimated capital costs for 1981-1990 are $387 million, with total annual costs for that decade of **$3.64** billion (also 1981 dollars).[56] **Eight copper smelters closed permanently from 1979-86, some because of age or cutbacks in domestic mine production, but some because the cost of installing a new furnace and adding an acid plant was too great.** Additional investments have been made since, and the remaining 8 smelters are in compliance with the Clean Air Act. Present levels of control entail capital and operating costs of between 10 and 15 cents per pound of copper.[57]

In comparison, copper smelters in Canada, Chile, Mexico, Peru, Zaire, and Zambia—among our major foreign competitors—are not faced with similar environmental regulations. If smelters in these countries are controlled at all, it is only to the extent that sulfuric acid is needed for leaching. Thus these countries achieve from O to around 15 percent capture of the input sulfur, or about one-fifth of the present level of U.S. control. Japanese smelters achieve 95 percent control as part of government policy to subsidize sulfuric acid production to supply the Japanese chemical industry.[58] Information regarding the costs of acid production in these countries is not available.[59] Future capital investments in Chile, Mexico, Peru, Zaire, Zambia may be funded in part by the World Bank (see ch. 3). The World Bank requires environmental controls as a condition for financing, but the standards are less stringent than those in the Clean Air Act.[Go]

Costs also were incurred by the domestic industry because of changes in the emission limitations and allowable means of control, and the deadlines for meeting them. Several smelters installed technologies that seemed promising at the time, but later failed either in producing copper

53MacDonnell, supra note 7

[54] Supplemental control systems use very tall stacks to disperse pollutants, thus diluting their ambient concentration. Intermittent control consists of monitoring the ambient weather conditions to identify when wind patterns and temperature inversions could trap the pollutants near the source instead of dispersing the plume. Under these conditions, production is cut back to the point necessary to reduce pollutant emissions to an acceptable ambient concentration.

55Arthur D. Little, Inc., *Economic Impact of Environmental Regulations on the United States Copper Industry* (Washington, DC: U.S. Environmental Protection Agency, January 1978).

56Mac Donnell, supra note 7.

57Everest Consulting, Air Pollution Requirements for Copper Smelters in the United States Compared to Chile, Peru, Mexico, Zaire and Zambia, 1985.

[58] *CRU Copper Stud\ es,* supra note 4; see discussion of trade in ch. 4.

59MacDonnell, supra note 7.

60 Everest Consulting, supra note 57.

or **in controlling emissions (e. g., the Hoboken converter at Inspiration Consolidated Copper Company, and the Arbiter process at Anaconda's Butte smelter). Without major technological advances, further environmental regulation (e.g., the suggested 1-hour sulfur dioxide standard or mine waste management under Subtitle C of RCRA) could bring further reductions in domestic mining and smelting capacity.**

Given the health and safety implications of reducing the number of environmental regulatory requirements in the United States, that is an unlikely option. However, introduction of similar requirements in foreign copper-producing countries could "level the playing field" and reduce the impact of domestic regulation on competitiveness. It also would improve the quality of the environment in those countries. **While the United States government has no direct control over foreign environmental regulation, we can have indirect influence through trade and financing, as well as treaties.**

For example, U.S. participation in international financing of foreign copper projects (through the World Bank and its affiliate banks) could be used to apply pressure for environmental controls. One example would be to provide incentives through variable interest rates tied to the degree of control. Tariffs on imported copper also could be tied to the degree of control in the country of origin, although at present there are too few data to make this workable.

Treaties related to border issues also can influence foreign control. The difference in level of control is one issue in the U.S.-Canada Free Trade Agreement. The United States and Mexico signed an agreement January 29, 1987, to control air pollution caused by copper smelters along their common border. Under the agreement, Mexico guaranteed that, by June 1988, SO_2 emissions at the Nacozari smelter will not exceed 0.065 percent by volume during any 6-hour period. This is identical to the U.S. standard for new sources. In the interim, ambient SO_2 concentration levels will not exceed 0.13 parts per million over a 24 hour period (the U.S. standard is 0.14 ppm).[61]

61 "U. S., Mexico Agree to Control Pollution from Copper Smelters Near Common Border," *Environment Reporter, vol.* 17, No. 42, Feb. 13, 1987, p. 1738.

Research and Development

Research and development could result in process and product technologies that would significantly improve the competitive position of the domestic copper industry. Technological innovations developed and implemented within the last 10 years helped the industry reduce their costs of production and increase productivity. Additional R&D, especially in areas where the United States is at a competitive disadvantage or has unique resource endowments, could provide further boosts to competitiveness. For example, domestic mines haul larger amounts of ore greater distances, making improvements in haulage productivity especially advantageous in the United States. Similarly, in situ solution mining would enable U.S. companies to exploit large oxide ore resources without having to haul the ore. This section reviews Federal R&D funding mechanisms; private initiatives are discussed below.

There is no comprehensive Federal policy toward R&D. Legislation intended to further specific policy goals may authorize expenditures for R&D (although actual appropriations may fall short of the authorization). For example, the National Materials and Minerals Policy, Research and Development Act of 1980[62] was intended to provide a basic coordinating framework for executive branch materials policy decisions. The Act encompasses all materials related to industrial, military, and essential civilian needs. It emphasizes, however, strategic materials for which the United States is heavily import-dependent but could augment supplies through substitution, recycling, and conservation. The Act also emphasizes the importance of government support for R&D in addressing materials problems.

The Act required the President to formulate a materials and minerals program plan. President Reagan submitted this plan to Congress in April 1982. His report focused primarily on minerals availability issues associated with Federal lands and on management of the stockpile; it placed little emphasis on R&D. The plan assigned responsibility for coordination of national materials policy to the Cabinet Council on Natural Resources

62 P. L. 96-479.

and the Environment. Coordination of R&D not involving policy questions was assigned to the Interagency Committee on Materials (COMAT), under the direction of the White House Office of Science and Technology Policy.

Although President Reagan's plan has been criticized heavily both in concept and implementation,[63] strategic materials R&D funding has fared fairly well. In addition, initiatives have been undertaken that were not specifically identified in the plan, such as creation of a National Strategic Materials and Minerals Program Advisory Committee within the Department of the interior.[64]

R&D funding for minerals and materials also may be provided as part of an agency's overall program responsibilities. For copper production and related technologies, this would include primarily R&D sponsored by (and often actually carried out by) the Bureau of Mines and Geological Survey, both within the U.S. Department of the Interior (see table 10-4).

The Bureau of Mines conducts basic and applied research on all types of minerals to improve understanding of the principles of mining and mineral processing and to reduce associated health hazards. Their R&D budget for FY 89 is expected to decrease by $10 million to $86 million.[65] The proposed decrease was in applied research, which the Reagan Administration believes is the responsibility of private industry.[66]

The Geological Survey undertakes research on the extent, distribution, and character of mineral and water resources; on geologic processes and principles; and on the development and application of new technologies, including remote sensing, for mapping. Their total R&D budget for FY 89 is projected to be $224 million, a decrease of $12 million from FY 88.[67]

Some Federal (and private) R&D money goes to support research programs at u diversities, including the State mineral institutes and the Bureau of Mines mineral technology centers. The mineral institutes originally were administered by the Office of Surface Mining; responsibility subsequently was transferred to the Bureau of Mines. proposals to abolish the institutes have been included in almost every budget request since 1982. Special legislative initiatives also have provided for research centers, such as the 1 -year grant for the new Center for Advanced Studies in Copper Research and Utilization at the University of Arizona, whose mandate focuses primarily on copper product applications (such as superconductors), but also includes research on process technologies (e.g., in situ solution mining).

Research funding for universities not only provides a valuable source of technological innovation for the minerals industry, but also supports education and training for the next generation of industry employees. Enrollment in mining and other engineering disciplines historically has been cyclical, and currently is low due to the poor economic performance of the minerals industry during the early 1980s. In 1978, 3,117 undergraduate students were enrolled in 26 mining engineering programs in the United States. By 1987, the number of programs had dropped to 19, with additional closings and mergers expected. As a result, significant shortages of mining engineers are predicted at least through 1992.[68] Evidence of Federal support for truly innovative R&D could salvage some university programs and attract high quality students.

More specialized research on applications for copper is funded by the National Bureau of Standards (e.g., specialty alloys) and the Department of Energy (for example, materials for transmission lines or solar energy systems). The National Aeronautics and Space Administration also funds some research on remote sensing that could be applicable to mineral exploration. The

[63] See, e.g., U.S. General Accounting Office, *Implementation of the National Minerals and Mater\. ?/s Policy Needs Better Coordination* and *Focus* (Washington, DC: U .S. General Accou nting Office, Mar, 20, 1984), GAO/RCED-84-63.

[64] OTA, supra note 40.

[65] The total Federal expenditures for R&D in 1986 were $14 billion. Although the United States spends more on R&D than any other country, it continues to lag behind some of its competitors in the share of gross national product devoted to civilian R&D. While Japan spends nearly 3 percent of its GNP on R&D, the U.S. share is only slightly above 2.5 percent. see "R&D Sc ore board," *Business Week*, June 22, 1987

[66] Office of Management and Budget, *Special Analyses: Budget of the United States Government, Fiscal Year 1989* (Washington , DC: U.S. Government Printing Office, 1988).

[67] 1 bid.

[68] Eileen Ashworth, "Where Have All the Graduates Gone, ' *LANDMARC*, January/February 1988.

Table 10-4.– Federal R&D Expenditures Related to Mineral Resources and Production (1,000 current dollars)

Year and budget category	Bureau of Mines	Percent of total	USGS	Percent of total
1974, *total budget:*	$81,689		$172,324	
Geological and mineral resource surveys and mapping			43,340	25%
Metallurgical research	15,779	19%		
Mining research[a]	39,267	48		
1975, total *budget,*	148,820		254,146	
Geological and mineral resource surveys and mapping			76,268	30
Metallurgical research	17,995	12		
Mining research[a]	50,437	34		
1976, *total budget:*	158,818		272,836	
Geological and mineral resource surveys and mapping			102,203	37
Metallurgical research	21,744	14		
Mining research[a]	87,279	55		
1977, *total budget:*	133,611		320,433	
Geological and mineral resource surveys and mapping			96,870	30
Metallurgical research	22,593	17		
Mining research[a]	33,329	25		
1978, *total budget:*	138,200		375,899	
Geological and mineral resource surveys and mapping			112,708	29
Metallurgical research	25,023	18		
Mining research[a]	46,431	34		
1979, *total budget:*	148,476		418,519	
Geological and mineral resource surveys and mapping			131,640	31
Mineral resources and technology	33,680			
1980, *total budget*[b]	134,033		469,862	
Geological and mineral resource surveys and mapping			143,039	30
Mineral resources and technology	29,727	22		
1981, *total budget:*	142,319		516,056	
Geological and mineral resource surveys and mapping			160,027	31
Mineral resources and technology	24,883	17		
1982, *total budget:*	150,602		507,846	
Geological and mineral resource surveys and mapping			163,706	32
Minerals and materials research	32,003	21		
Mineral institutes	9,244	6		
1983, *total budget:*	$144,568		$371,784	
Geological and mineral resource surveys and mapping			159,096	42%
Minerals and materials research	29,680	21%		
Mineral institutes	9,152	6		
1984, *total budget:*	136,855		377,672	
Geological and mineral resource surveys and mapping			164,289	43
Minerals and materials research	32,754	24		
Mineral institutes	9,350	7		
1985, *total budget:*	135,959		416,368	
Geological and mineral resource surveys and mapping			169,595	40
Minerals and materials research	31,944	23		
Mineral institutes	7,822	6		
1986, *total budget:*	127,711		412,306	
Geological and mineral resource surveys and mapping			169,356	41
Minerals and materials technology	30,692	24		
Mining technology	12,808	10		
Mineral institutes	7,677	6		
1987, *total budget.*	140,412		431,193	
Geological and mineral resource surveys and mapping			168,656	39
Minerals and materials technology	32,208	23		
Mining technology[a]	18,598	13		
Mineral institutes	7,642	5		
1988, *total budget:*[b]	146.398		447,997	
Geological and mineral resource surveys and mapping			176,430	39
Health, safety and mining technology	53,167	36		
Minerals and materials science	27,092	19		
Mineral institutes	9,160	6		
1989, total *budget:*[b]	126,605		425,253	
Geological and mineral resource surveys and mapping			167.767	39
Health, safety and mining technology	37,735	30		
Minerals and materials science	23,440	19		
Mineral institutes	0	0		

[a]Includes research related to environment and health and safety.
[b]All 1988 and 1989 figures are estimates.
SOURCE: Office of Management and Budget, *Budget of the United States Government* (Washington, DC: US. Government Printing Office, various years)

U.S. Environmental Protection Agency is responsible for R&D on pollution control technologies. Finally, the Department of Defense conducts research on materials for ordnance, weapons systems, etc.

Federal tax policy also can affect private funding for R&D, e.g., by providing tax deductions tor credits for R&D expenditures or for demonstration projects featuring unproven technology. Unless "R&D" is defined very narrowly, however, industry can interpret it broadly with corresponding high revenue losses.

Industrial Policy

"industrial policy" was the political philosopher's bromide of the early 1980s, as "competitiveness" has become the catchword for the mid-80s. Development of a coherent and consistent Federal policy toward industry, and then toward improving domestic industrial competitiveness, was widely touted as the solution to industrial ills. Such an integrated policy scheme is still absent in the United States.

Instead, current Federal competitiveness policy is to rely primarily on private initiatives and the market. When the importance of a particular industry (e.g., for national security) or the extraordinary scope of market changes seems to merit public intervention, there are few policy instruments for actively promoting domestic competitiveness. Instead, government actions have focused on trade protection, including Orderly Marketing Agreements (bilateral agreements to restrict imports into the United States), ad hoc agreements, and tariffs.

Protectionist policies insulate American producers from incentives to adjust to foreign competition. They also can distort markets in ways that require increasing protection. For instance, although Orderly Marketing Agreements usually are intended to give American firms time to adjust to changing market conditions, the restrictions on imports from one country can encourage new producers in other places. Moreover, limiting the volume of imports can induce U.S. fabricators to shift to other materials, and foreign producers to shift to higher-value goods to preserve their foreign exchange.[69]

Other policies that introduce market distortions include direct or indirect subsidies, and dumping (selling exports at prices less than charged in domestic markets, or at less than cost). Policies of promotion and subsidy pursued by LDCs are a particular problem. While they may reduce the cost of goods to domestic consumers, they also disadvantage domestic producers. In addition, as discussed in chapter 4, the Japanese smelting industry receives direct and indirect subsidies to promote sulfuric acid production. The Canadian smelters also receive government assistance in financing pollution control. Of course, domestic companies also have obtained direct subsidies (see box 10-A, below).

Although the domestic copper industry survived the economic vagaries of the early 1980s without significant government assistance, they lost a lot of money and capacity in the process. Their ability to survive a similar slump within the next 5-10 years could depend on government support now to actively promote domestic competitiveness. One of the keys to continuing competitiveness is the ability to innovate, which in turn is dependent on capital formation, or investment in plants and equipment embodying new, more efficient technologies; education and job training programs; and the development of new commercial products and processes.[70]

Thus, **policy support for continuing competitiveness would have to include both micro- and macroeconomic policies.** The former includes anti-trust, trade, defense, patent, tax, job training and education, environmental protection, and R&D policies. These are considered macroeconomic because each policy directly or indirectly affects ability of companies to compete with foreign-based companies in domestic and key export markets). The second group covers fiscal and monetary policies. Fiscal policy is important because it establishes the level of overall output, inflation, and employment; and because government borrowing to finance deficits influences interest rates, both for industry itself, and for primary and secondary consumers.[71]

A consistent and integrated set of government policies can gradually turn a temporary comparative disadvantage in capital- or education-intensive commodities into an advantage. Seen in this light, the growing comparative advantage of Japan[72] and the declining share of U.S. producers result to no small degree from different national investment efforts influenced by different government policies.

Although a well-designed and supportive industrial policy is not by itself sufficient to build competitiveness in a given economic sector, government policies may tip the balance. The United States can expect no more than very limited success in negotiations with other nations aimed at minimizing the impacts of those countries' indus-

[69] Zysman and Tyson, supra note 3.

[70] Guenther supra note 2.

[71] Ibid.

[72] Japanese government policies toward development of their smelting industry are described in the section on Trade in ch. 4.

trial policies. Better prospects for strengthening the U.S. position would come with the adoption of more effective industrial policies of our own.

A third option is to provide direct product support. This might include increased use of domestic copper in coinage, or mandated use of domestic copper products in governmental activities (e.g., plumbing and wiring in Federal buildings). Coinage reform has been proposed for several years, including increased copper content of the penny (which is currently 95 percent zinc—mostly imported) and a copper dollar coin. **While** such measures **may be small potatoes in terms of overall copper demand, they are symbolically important in demonstrating Congressional support for domestic products.**

INDUSTRY STRATEGIES AFFECTING COMPETITIVENESS

Domestic copper companies undertook a number of initiatives from 1980-1987 in order to reduce their costs of production and improve their competitive position. These are summarized in table 10-5. Aside from direct cost reductions such as those obtained in the labor negotiations of 1986, these actions can be grouped in three rough categories—actions that resulted in significant corporate restructuring, those that required capital investment, and those that reduced production and/or capacity. Two companies also received significant local government support and renegotiated labor and service contracts in order to re-open mines (see box 10-A).

Most companies invested in new technology for mines, mills, smelters, and refineries, or added low-cost SX-EW capacity. For example, automated controls at all stages of copper production provide increased operating efficiency and are now installed at almost all operations. Those companies that had not yet modernized their smelters and/or furnaces did so. In addition, at least one operation—Kennecott—underwent major mine modification, including the addition of in-pit crushing and conveying equipment. PD also converted its Morenci mine from rail to truck haulage and plans to install in-pit crushing and conveying.

A few companies actually expanded their operations by either purchasing developed copper properties, or increasing the capacity of their existing mines or processing facilities. Copper Range improved mine and mill efficiency and thereby substantially increased throughput. For Asarco and PD, expansion was part of a strategy to improve the balance between mining and processing capacity. In Asarco's case, such a strategy was needed because they historically were not a mining company and wished to acquire a secure supply of feed for their smelters. For PD, a mine acquisition replaced mining capacity shut down or soon to be depleted. Cyprus also bought significant new capacity, in part to fill out their operations after they were spun off by Amoco Minerals, and in part to replace properties that were closed during this period.

Other companies cut back production in response to the decreased demand and increased imports of the early to mid-1980s. Partial capacity utilization is a sub-optimal policy for many mines, however. Full closure may be more advantageous if the closure costs are less than the mine's anticipated operating losses during the period of depressed prices.[73]

Several firms either sold or spun off all of their copper operations, and are no longer in the copper business in the United States. After purchasing Cyprus Mines in 1979, Amoco Minerals spun off this subsidiary to the shareholders in 1985. Similarly, Newmont Mining spun off 80 percent of Magma Copper (including Pinto Valley) in 1986. Newmont still owns shares in foreign copper properties. Arco/Anaconda, Cities Service, and Louisiana Land sold or closed permanently and wrote off all of their domestic copper operations.[74]

[73] Evans, supra note 10.

[74] Louisiana Land sold the Copper Range refinery to Echo Bay, which plans to sell it to Northern Copper Co. (operating as Copper Range) within the next couple of years.

Table 10-5.—Strategies Adopted by U.S. Copper Companies in Response to Economic Conditions, 1980-87

Strategy	Amoco Minerals[a]	Arco/ Anaconda[b]	Asarco	Cities Service[c]	Copper Range	Cyprus	Louisiana Land[d]	Inspiration[e]	Kennecott[f]	Magma	Montana Resources	Newmont[g]	Phelps Dodge
Strategies to cut losses (or raise capital):													
Sold copper properties (or shares)													X
Spun off properties to new company	X											X	
Closed mine(s) for foreseeable future	X	X	X			X						X	X
Closed mine(s) temporarily or cut production		X	X			X	X	X	X			X	
Closed smelter(s) permanently		X	X						X				X
Closed smelter temporarily							X		X				
Toll smelting only								X					
Closed refinery permanently		X							X				X
Closed refinery temporarily							X						
Sold non-copper properties													X
Diversified													X
No longer in U.S. copper business	X	X		X			X	X					
Strategies to improve competitive position:													
Bought developed copper properties			X		X	X					X	X	X
Opened new mine(s)			X						X				
Expanded production at existing mine(s)	X		X		X							X	
Major mine modernization									X				
Other new mining technology			X			X			X			X	X
Mill modernization		X							X			X	
Added SX-EW capacity												X	X
Replaced smelter furnace			X						X	X			
Other smelter modernization			X										X
Refinery modernization													
Built new refinery							X						
Improved balance between mining/processing			X										X
Obtained State/local govt. assistance					X						X		
Renegotiated labor costs					X	X					X		
New labor contract			X					X	X			X	X

[a]Copper properties spun off to Cyprus Minerals in 1985.
[b]Closed all properties; Butte, Montana operations sold to Montana Resources in 1985.
[c]Owned Duval; most properties sold or leased to Cyprus since 1985.
[d]Sold to Echo Bay Co. before Northern Copper was formed to own/operate the White Pine mine.
[e]Sold to Cyprus in June 1988.
[f]Sold Ray Mines to Asarco in 1986 and Chino Mines to Phelps Dodge in 1986.
[g]Spun off Magma (including Pinto Valley) as separate company in 1986, but retained a 15 percent interest.

SOURCE: Office of Technology Assessment.

Box 10-A.—State and Local Assistance and Cost Concessions Obtained by Montana Resources and Copper Range

In 1985, Washington Construction, a Montana-based firm, purchased the assets of Anaconda's Butte operations for $7 million intending to salvage them for scrap. After conferring with Anaconda's former general manager, however, Washington Construction determined that the mine and mill could reopen profitably. The State and local governments, eager to see the operation contributing to the economy once again, quickly granted the necessary permits. The State also procured a $12 million line of credit to underwrite startup costs. The county granted an $8 million tax cut. The company obtained a 12 cent/lb reduction in the transportation and refining costs Anaconda had paid to ship the concentrate by rail to California and have it processed in Japan. The local power company granted lower rates for electricity. Finally, the number of workers was cut almost 50 percent, and the top wage went from $22/hrto$13/hr. As a result, when the East Berkeley Pit reopened early in 1986 as Montana Resources, Inc., it was reportedly mining copper for 58 cents/lb, compared to Anaconda's 97 cents/lb.[1]

Louisiana Land purchased Copper Range (the White Pine, Michigan mine) in 1977, but closed the high-cost underground operation in 1982 to cut losses, In 1984, Echo Bay acquired most of the assets of Copper Range as part of the purchase of a Nevada gold mine. A year later, Northern Copper–a newly-formed firm consisting primarily of former White Pine managers and employees—bought the mine and smelter for $32 million. The financing was arranged by Salomon Brothers. The State of Michigan provided a $4. s million loan and about $3 million in training and grants. Before the mine reopened, a new labor contract was negotiated that brought total labor costs to below $12/hr, about $3/hr less than at other union mines.[2]

[1] 'There's a Gleam in the Eye of Copper Producers, *Business Week* 1986

[2] "U S Industry Responds to Dramatic Changes in World Role, ' *CRU Copper Studies*, vol 14, No 4, oct 1986

Future Industry Options

As a result of actions taken during the early to mid-1980s, the domestic copper industry is now competitive in world markets, although at the cost of production capacity and market share. However, next time the price drops— whether due to a recession or new producers creating an oversupply—it is likely to go lower than it did in 1984 (perhaps as low as 40 cents/lb), and stay low longer. To be competitive at that price, domestic producers will need entirely new process technologies (e. g., in situ solution mining) or a captured market. This will require investments in R&D now, as well as new ways of thinking about their product.

Research and Development.–Direct R&D spending in the primary copper industry is low, averaging less than 1 percent of sales in 1986.[75] This compares to an overall average for the metals and mining industry of almost 2 percent of sales (see table 10-6), and a national industrial average of 3.5 percent of sales.[76] The mining in-

[75] If exploration expenditures were included, this fraction would be higher.

[76] *Business* Week, supra nOte 65.

Table 10-6.—1986 R&D Expenditures in Selected Industrial Sectors

Sector	R&D expenditures as a percent of sales
Aerospace	4.5%
Automotive	3.7
Chemicals	4.1
Drugs	7.8
Electrical	3.3
Electronics	4,4
Fuel	0.8
Information Processing–Computers	8.3
Information Processing–Software	7.7
Instruments and Controls	6.7
Machinery–Industrial and Mining	3.3
Metals and Mining	1.8
Semiconductors.	12.2
Steel	0.5
Telecommunications	5.1
Textiles	0.8

SOURCE "R&D Scoreboard, " *Business Week,* June 22, 1987.

dustry considers exploration to be research, and traditionally has sought better deposits rather than better technology. Members of the copper industry argue that most innovations are developed by equipment vendors, yet the Industrial and Mining Machinery sector also lags behind the national average in R&D expenditures. Further, the U.S. mining machinery industry has consistently lost market share to foreign competitors throughout the 1980s, and currently is operating with substantial excess capacity.[77] If this trend **continues, their R&D expenditures can be expected to decline. Further** shifts of R&D to overseas also will shift the research's focus to solving foreign problems.

One option for increasing the level of R&D on production technology is for the domestic copper industry to actively pursue cooperative research ventures involving copper companies, vendors, universities, and government agencies. Anti-trust and patent concerns about such ventures were addressed in the National Cooperative Research Act of 1984 (P. L. 98-462). In the past, cooperative research has been limited to vendors or the Bureau of Mines borrowing plant space for small but time-consuming development and demonstration projects—often the most expensive aspect of R&D. Within the last year, all these groups have begun to explore avenues for cooperative research in an organized way. One concern is the continuity of funding from all parties once a project is underway.

New **Copper Products.-The domestic copper industry is still faced with competition for markets, both from foreign imports and from other metals and materials (e.g.,** aluminum). **If they want to offset further market losses, two basic options are available—expand sales in current markets or develop new products and uses for copper and market them aggressively.**

The companies argue that marketing for expansion would be futile because they already are selling all the copper they produce. In the same breath, they complain about idle capacity and low prices due to excess supplies. Simultaneously developing new markets and capturing a larger share of them could address both problems.

One key to expanding sales is marketing based on product differentiation. Superior quality may command higher prices in the marketplace, making production costs less significant.[78] Although, copper traditionally has been considered a non-differentiable commodity of uniform quality, at least one domestic company prides itself on the quality of its final product–copper rod. That company brags that its final metallurgical testing is good enough to produce a zero rate of rejects during wire manufacture. indeed, if a wire customer complains about breakage or other failures, the company sends consultants to visit the wire plant to trace the source of the problem there. Yet this company advertises neither the superior quality of its product nor its backup services. product differentiation based on quality is likely to become more important as specialty copper alloys and high-technology applications such as superconducting materials occupy an increasing share of the end-use market.

Similarly, copper has properties that make it superior to the materials that often are substituted for it. When faced with direct market threats (e.g., aluminum wiring in houses), copper industry associations have publicized the disadvantages of the substitute material. Yet neither individual companies nor their associations regularly advertise copper as part of a consistent strategy of market development. In contrast, one of copper's major competitors—the aluminum industry—regularly advertises both its product and its innovative research programs in the trade press.

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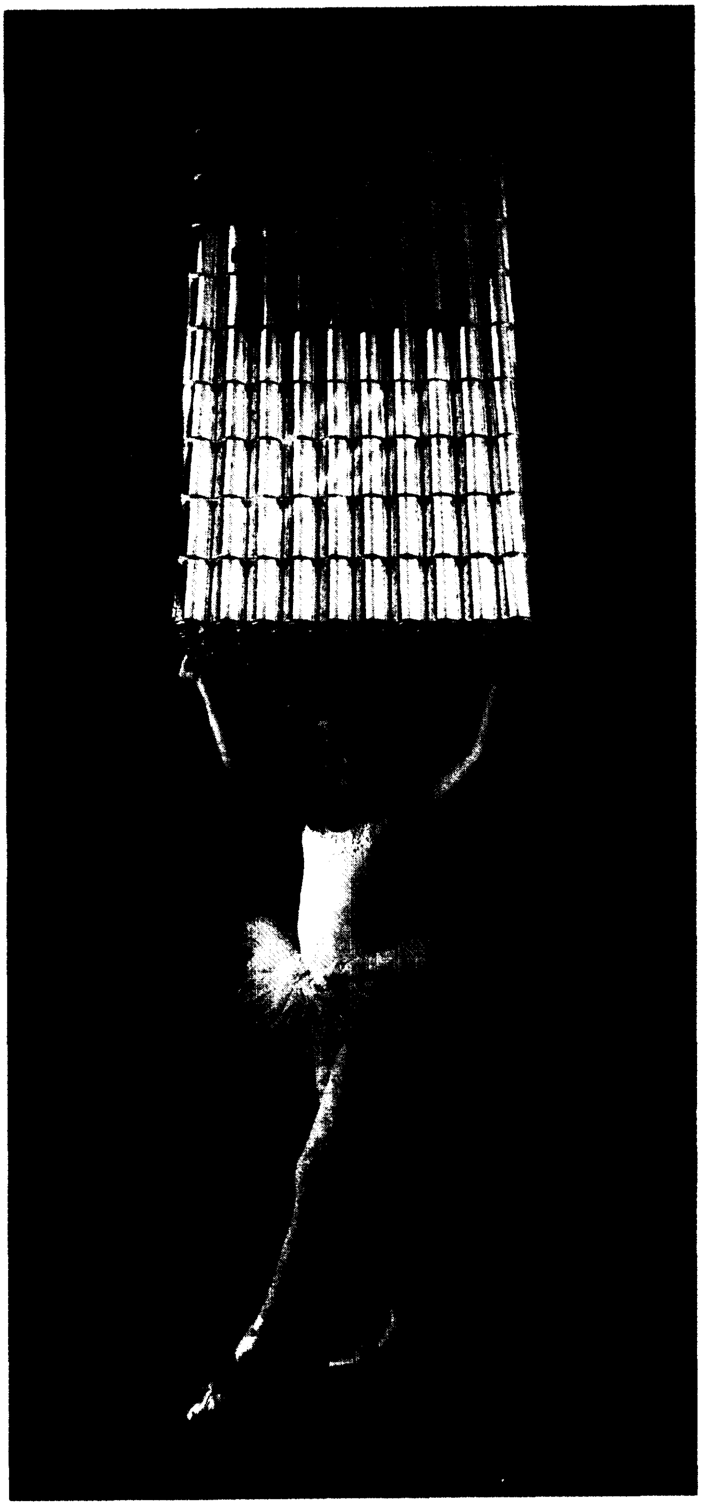
[77] ITA, supra note 8.

[78] Note also the difference in table 10-6 for R&D expenses for the two extractive industries (fuel and metals/mining), which see little opportunity for product differentiation, versus the remaining manufacturing and processing industries, which can profit from differentiation.



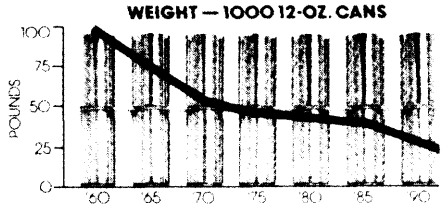
Where Muriel Gets Her Muscle

Mighty Muriel can lift 1,000 aluminum beverage can bodies.

No mirrors No invisible wires It's all done with a series of technological breakthroughs that have thinned the walls of the latest can bodies down to 0038:"

Early beverage cans were steel, 1000 empties weighed over 100 pounds. By 1975, new aluminum alloys had reduced the load to 43.5 pounds And today?

What Muriel is demonstrating is brains, not brawn. It's now practical to get 1,000 bodies out of 25 pounds of metal–because Alcoa scientists developed remarkably tough alloys for rigid container sheet the automated processing to keep thin sheet consistent in properties and gauge, and a whole family of new lubricants to adapt these ultra-thin gauges to high-speed processing by canmakers and beverage companies.



And now, for an encore...

These same advances plus a few more have made aluminum competitive not only for beverage cans but for food cans as well. And we've been working on new laminates. composites, and polymers that will figure prominently in the comingage of aseptic and high-barrier food packaging.

We're out to make a material difference, and our progress is accelerating.

For a closer look at what's happening at Alcoa Laboratories, send for our book, The Material Difference.
Write to Dr. Peter R. Bridenbaugh,
Vice President–Research &Development,
Box One, Alcoa Laboratories,
Alcoa Center, PA 15069.

ALCOA

Photo credit: Engineering and Mining Journal

An aluminum company advertisement highlighting product research.

Another aspect of product differentiation through marketing is based on the advantages of purchasing from domestic producers. For example, orders can be filled more quickly. **In the past, fabricators and manufacturers** often held large stockpiles as hedges against price increases and/or supply shortfalls. In today's tight economy, this can be disadvantageous to cash flow. Many consumers already have changed their purchasing policy to smaller stockpiles; using domestic supplies facilitates this policy. Reliance on domestically-produced copper also would make return and replacement of defective products simpler.

Finally, a "Buy American" campaign backed up with ads about the problems faced by the domestic copper industry could be very effective—especially if aimed toward the effects of imports on domestic capacity and employment. Purchasing foreign products and components means not only losses of present domestic employment and market share, but also the advancement of foreign manufacturing expertise and thus future market share. This includes larger volumes over which to spread manufacturing, tooling, and R&D costs; an accelerated learning curve; and expanded opportunities for innovation, and process development and demonstration. [79]

R&D for developing new products and uses for copper shares a common problem with research on mining and processing technologies—the primary copper industry assumes the consumers (including the government) will take the initiative. Associations representing the primary copper industry regularly publicize promising new applications, but do little direct research. Yet other metals in decline have found cooperative R&D with major consumers on new products very promising. Box 10-B presents an example from the steel industry.

[79] K. K. Kappmeyer, "Steel/Auto Partnership: A Blueprint for Competitive Advantage," *Materials and Society,* vol. 11, No. 2, 1987.

Box IO-B.—Cooperative Steel/Auto Industry Research[1]

In the early 1980s, the steel industry began to take an active role in dealing with trends related to substitution of materials, and foreign capture of markets, for steel parts in the automotive industry. This began as a defensive move and gradually shifted to aggressive action to create a domestic competitive advantage.

The American Iron and Steel Institute (AISI), the trade association for the North American steel industry, has an Automotive Applications Committee that sets priorities for, and commissions original research on, the use of steel in the automotive industry. It also educates the U.S. automotive industry about the effects of materials substitution on domestic competitiveness (i e., the Japanese auto industry is more competitive with steel parts than the domestic industry is with plastics and composites).

Recognizing that the competitive futures of the American steel and auto industries are intertwined, the steel industry began seeking solutions that would help both. An early initiative was seminars for steel industry executives; the speakers were advanced product engineers in the auto industry. The aim was to discuss differences between what the steel industry was producing (under 30-year old process and product standards) compared with what the auto industry needed.

The seminars resulted in three major projects: 1) a design manual prepared by a task force of 9 steel company representatives, 13 auto company advisors, and a wide variety of outside consultants in, e.g., welding and computerized structural design; 2) a commissioned study of the relative tooling costs for steel and plastics to determine what influences steel tooling costs and to initiate steps to lower them; and 3) analyses of gauge specifications, materials characteristics and uniformity, and manufacturing costs and their relationships to product uniformity, intended to reduce auto manufacturing costs.

In addition, this steel/auto partnership established a University Steel Resource Center at Northwestern University. The Center aims to bring steel producers and consumers together to work on common technical and institutional issues. AISI provides direct funding; Northwestern obtains State and local support.

[1] K K Kappmeyer, "Steel Auto Partnership A Blueprint for Competitive Advantage," *Materials and Society*, vol 11 no 2 1987

The chief advantages of the strategies described in box 1O-B are knowing the needs of the consumers and being able to find ways of serving those needs with copper rather than alternative materials. Attempts to ascertain customer needs also create a positive external image that would be useful in designing marketing and promotion policies.

One difference between the steel industry example and the copper industry is that very exacting standards for particular uses of copper have existed for some time (e.g., electrolytic copper, oxygen-free copper; see ch. 6). However, steel industry studies will produce analyses of "as received" variability, which could support marketing based on product quality. In the copper industry, similar analyses could examine the extent to which delivered products met established standards (e,g, based on percentage of product returns for failures during fabrication or manufacturing), and therefore consumer costs associated with such failures.

A second approach to giving more attention to demand is modeled on the aluminum industry's strategy. Trends in aluminum originally were similar to those in copper. Aluminum production expanded into a global business, and the U.S. share of world capacity dropped. Although most ore had always come from overseas mines, they were controlled by U.S. firms. Then many foreign mines were nationalized, and a growing percentage of new capacity is government-controlled. The LME and COMEX began trading aluminum ingot, and prices became volatile. Scrap emerged as a growing source of supply. Expanding foreign trade meant the United States became a net importer of ingot and increasingly of semi-fabricated aluminum products. Profits dropped and some companies went out of the aluminum business. Others pursued strategies to ensure their positions as viable aluminum producers with long-term profitable growth. These strategies were much the same as those followed by copper producers (plant modernizations, renegotiated contracts, etc.) with one major exception—the aluminum industry expanded into more value added aluminum products and related businesses (see box 10-C).

Box IO-C.—Forward Integration in the Aluminum Industry[1]

To maintain profitability, many of the **major aluminum companies have undertaken strategies of forward integration into value added products and/or diversification into non-aluminum (but mostly materials-related) businesses.** Alcoa has done both simultaneously. In the value added products area, Alcoa is now producing aluminum memory disks for the computer industry instead of just aluminum blanks. Alcoa hopes to have 25 percent of sales from non-aluminum products by 1990, up from 10 percent in 1984. They have acquired a defense materials research company, and are applying what they know about aluminum to other materials to aid in ventures in structural ceramics, chemical separations, and polymer packaging.

Reynolds is continuing to pursue fabricated and value added aluminum products. They introduced a new line of aluminum can sizes plus a new nitrogen technology for packaging. Also, combining aluminum and plastic, Reynolds has developed a lightweight meal pouch for military use.

Kaiser already was very diverse, including oil and gas ventures, and real estate. They have now forward-integrated into aluminum memory disks.

Alcan entered the U.S. market by purchasing Arco's aluminum assets. They are developing the new business through new projects, joint ventures, and acquisitions in the areas of aerospace, packaging materials, electronics, and communications and transportation markets.

[1]Joseph J. Tribendis, "The U.S. Aluminum Industry: Into Its Second Century, " *Materials and Society,* vol. 10, no. 2, 1986.

A significant difference between the two industries is that copper historically has experienced demand growth from electricity and communications. Thus investment strategies focused on production rather than consumption. As the number of copper producers grew, the companies dis-integrated vertically. The technologies associated with fabrication and manufacture of copper products became standardized, which led to numerous independent fabricators.

In the aluminum industry, in contrast, early high prices limited use and cheaper and more abundant metals captured markets. When the aluminum price did come down with the invention of electrolytic processing, the major companies adopted aggressive market expansion as their central policy. They integrated vertically toward production of consumer products, created new applications through R&D, and undertook an intensive campaign to publicize and promote the advantages of their products. This strategy made it possible to charge lower prices for products competing with those manufactured from copper, steel, brass, pewter, or glass, and thus capture a significant share of those markets.[80]

Aluminum's success highlights the advantages of integrating operations forward to create demand. Yet during the copper industry's recent restructuring, significant further dis-integration occurred. Although most major U.S. copper refineries also produce continuously cast rod, most ties between copper mines and wire and brass mills have been severed. Historically, these ties were valuable to ensure low-cost, secure supplies of copper. With the changes in pricing, and the increased supply of foreign copper and scrap, however, the traditional reasons for strong ties between mining and fabrication have disappeared. For example, in 1980, PD had 15 mills and plants producing tube, brass and bronze alloy products, cable wire rod, and other manufactured products. As part of their asset restructuring program, PD has since sold all of their downstream fabricating and wire business except magnet wire.

Essentially, the copper producers consider vertical integration to be competing with their customers. Demand growth is no longer rapid, however, and coupling forward integration with the development of new products and uses could be effective in helping the domestic copper industry retain their market share.

[80] Jose Luis Mardones et al, "The Copper and Aluminum Industries: A Review ot' Structural Changes, " Resources *Policy,* March 1985,