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MARKETING OF COPPER IN THE WORLD AND ITS IMPLICATIONS

by

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ABSTRACT

Copper, one of the first metals to be employed by man, has been, is, and will be of great importance in the development of the human civilization due to a combination of its characteristics which make it suitable for a great variety of uses. This thesis discusses the international marketing of copper. The main objective is an understanding of the copper market with emphasis on analysis of wide price fluctuations of the metal. The trade of copper involved producers, most of them in developing countries and consumers, most in developed countries. The producers and consumers are widely dispersed without a defined pattern of trading among specific areas. For this reason, the geographic scope of the thesis is world-wide with the exception of the eastern countries of the Communist world. The analysis leads to recommended actions and conclusions regarding the copper market.

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INTRODUCTION

It is less than a century since the yearly output of the world's copper mines reached a total of 100,000 tons. By the beginning of this century, production was at 500,000 tons and it took only 30 years more to reach 2 million in 1930. By 1960, it had doubled to 4 million and in 1974, the primary production of the world (including U.S.S.R) was around 8.5 million tons.

This great increase in production as well as in consumption patterns has been due to several characteristics, the most important being the following:

- High electrical and thermal conductivity
- Ability to be alloyed with many other metals to produce materials with a wide range of properties.
- High resistance to many corrosive environments.
- Ease of working and forming by conventional industrial processes.
- A good combination of mechanical properties, including tensile strength, elongation, and hardness.

- Ease of jointing by soldering and brazing
- Good electro-deposition characteristics
- Suitability for ordnance (architectural, artistic, and decorating) purposes

The copper industry is one of great complexity and millions of people in the world in a direct or indirect way, depend upon it. One of its most interesting and difficult facets is concerned with the marketing activity. Today where the control of a big share of the industry is changing hands, it is appropriate to examine and analyze this activity.

With the exception of the U.S., which is the biggest producer and consumer in the world, the other developed countries in the European Continent and Japan are more dependent every day on developing countries to get copper for their necessities. Developing countries such as Chile, Peru, Zaire, and Zambia sell copper to the industrialized countries as concentrates, blister, and refined copper. Developed countries have large capacity in the smelting and refining, and practically a monopoly of the last step of the copper industry, that is, the fabrication (pipes, tubes, sheets, etc.).

Actually, developing countries like those named above have as immediate target to sell all their copper production

as refined copper and as a long-run target to expand into fabrication. If such goals are reached, it would mean major changes in the ways of marketing copper.

This thesis is divided in six chapters in order to cover the principal aspects of the copper market.

Chapter 1 is devoted to analysis of the behavior of the two biggest commodity exchanges in the world, that is, the London Metal Exchange Market, and the New York Commodity Exchange, which are of major importance in the determination of copper prices.

Chapter 2 is concerned with CIPEC, the copper cartel organized by the major copper producing countries. The chapter analyzes the organization of CIPEC and predicts the future behavior and influence on the market.

Chapter 3 analyzes substitution in copper markets and includes an analysis of the principle strengths and weaknesses of copper in relation to substitutes. The analysis leads to conclusions about the future of copper in its present markets.

Chapter 4 is dedicated to analysis of supply and demand of copper in the world market. Emphasis is on the tremendous changes in copper price. Special attention is given to copper scrap and its influence on the market.

Chapter 5 makes an evaluation of further processing (the fabrication step) by developing countries in the future and, finally, the last chapter, is concerned with the past, present, and future price trends taking into consideration all the concepts, complexities, and conclusions reached in the previous chapters.

CHAPTER 1

FUNCTIONING OF MAIN METALS MARKETS

Copper prices are determined by the law of supply and demand in the largest commodity exchanges of the world, the London Metal Exchange, and the Commodity Exchange of New York, well-known as LME and Comex, respectively. It is then worthy to study how these metal exchanges behave in order to get some insight as to how to formulate judgements about their incidence on copper price volatility.

As was proved some years ago, there is a relationship between price fluctuations and the exchanges. Prain, in his book, Copper - The anatomy of an Industry (1975), cites that before the 1973-74 price peak, a study was made to measure the price fluctuations of major metals. The standard deviations of average annual price for each metal were expressed as percentages of the average price during the year. The analysis found that over a sixteen-year period, zinc had a coefficient of variation of 30 percent, lead 29 percent, copper 27 percent, and tin 22 percent. These were the four metals then dealt in on the LME, later to be joined by silver.

No other metal had a standard deviation greater than 20 percent during this period.

This chapter studies the policies and procedures of LME and Comex, finishing with inferences about their impact on copper price fluctuations.

1.1 London Metal Exchange

The LME enables producers to sell their products at any time in any quantity at a known market price. It provides consumers with the facility to purchase supplies of raw materials at all times. Its daily quotations for copper, lead, zinc, tin, and silver are recognized widely in the world.

In copper, lead, and zinc the minimum contract is 25 metric tons and dealings are transacted in multiples thereof. In tin, one deals in multiples of 5 metric tons, while in silver the minimum contract is 10,000 ounces. The minimum units of trading are known as warrants.

There are two trading periods each day, one which opens precisely at noon (midday session), and the other in the afternoon (afternoon session). Each of the metals is sold over a period of exactly five minutes. There follows a ten-minute interval during which merchants and brokers have time to telephone their offices or their clients. The process is then repeated in a second ring. The "official closing prices" issued by the Exchange always relate to the midday session.

The afternoon market, which is technically unofficial, sometimes generates greater volumes of business. One of the reasons why the LME holds an afternoon session is due to the fact that New York, which is five hours later in relation with London Time, may generate the need for further transactions.

When the closing prices have been announced, the "Kerb Market" begins up to 1:30 p.m. midday, and 4:40 p.m. in the afternoon according with the Exchange regulations. This is a very informal market and members having late orders to fulfill stand together in the center of the Ring and call bids or offers for the five metals indiscriminately.

The London Metal Exchange has a market for futures up to three months. This market for futures or hedging facilities has immense attractions. The best way to explain the hedging procedure is by means of examples.

An example of how hedging can work to an advantage is as follows: A fabricator has sold 100,000 pounds of copper sheet at a fixed price for delivery to a shipbuilder in four months. The price of copper at the time of signing the contract was 68¢/lb. In order to protect himself, the fabricator immediately buys copper futures at the current price of 68¢/lb. He then places his order for copper through normal channels for delivery in three months. Three months later

the copper is delivered to him and the price is 75¢/lb. This is a loss of 7¢/lb., however, the fabricator can sell his futures at 75¢/lb. applying the profit on the futures contract against the higher price of purchased copper.

It should be emphasized that hedging is a means of removing the risk of price movements. Sometimes hedging may prevent a loss and sometimes it may prevent a profit. Then, the prime aim and object of hedging, which is in reality a form of insurance, is to protect various buyers and sellers against changes in price structure brought about by world events.

When a merchant wishing to protect a position by selling forward did not find an appropriate buyer, he would need to complete the deal with a professional risk-bearer, or "speculator," Initially, the speculator had a passive role, but with the creation of standardized contracts and hedging facilities, new opportunities were opened for the speculator.

From the point of view of the Exchange, the presence of speculative capital is indispensable to successful hedging operations, because the speculator is always prepared to buy or sell forward contracts at a favorable price.

The London Metal Exchange has two main categories of members. First, those who are known as Ring members. This category is restricted to principals of merchant or broker

companies, and many of them are both. The other category is known as non-dealing members, who have no "Ring-rights."

When a session is in operation, bids and offers are done orally by the Ring members to each other across the Ring. The "Non-Ring members" are behind the Ring-members. They are firms whose interest in metals is such that they need to keep in close touch with the market and from time to time give buying or selling orders to one of the Ring dealers.

For 95 years the LME has played an important role in the international market trade and its major policies and procedures have been described above.

1.2 The New York Commodity Exchange

The New York Commodity Exchange was created in 1933 as a merger of the National Metal Exchange in New York, the Hide Exchange, the Rubber Exchange of New York, and the National Raw Silk Exchange, and as its name implies, it is located in New York City.

Comex deals in six metals: copper, lead, zinc, tin, silver, and mercury, and a variety of other commodities including hides and rubber. It provides a hedging facility as far as 12 months, against the LME's 3 months, but neither of these facilities nor its prices are used by producers and consumers in the world (with the exception of U.S.A.) to the

same extent as is the London Market. However, Comex has taken over the LME's role as a residual market for surplus production because the U.S.A. is the biggest producer of metals but also it is the biggest consumer in the world and this pulls great amounts of metal into Comex.

Trading in metals was suspended, as the LME was, due to the Second World War in 1941 when the U.S. Government assumed control of stocks and prices as a war-time measure.

Comex is a membership organization, currently having 55 members trading in metals. Memberships in the Commodity Exchange are owned by individuals representing various sections of trades connected with the commodities dealt with on the Exchange, together with brokerage and commissions firms. Each member owns a seat on the Exchange, and these seats are bought and sold under rules prescribed by the Exchange. The trading floor of the Commodity Exchange is a large room with two separate "Rings" for trading metals, one for copper and mercury, and one for silver, lead, tin, and zinc.

Contracts may be made between members, or between a member and a non-member, who is represented by a brokerage firm which is also a member of the Exchange. Bids and offers have to be made audibly at the appropriate "ring" during the four or five hours of trading. Comex itself neither buys nor sells future contracts, nor does it in any way set prices at any time.

The price of futures is set by members bidding on the floor.

At the start of the day's trading there is an "opening call" in each trading ring, at which an executive of the Exchange calls for bids and offers for each trading month, namely the current month and the eleven succeeding calendar months. One minute before the closing time in each trade ring, a warning gong is sounded and a closing one minute later. Business done between these two gongs constitutes the closing price, which is officially disseminated.

Comex's contracts for the various metals must be of a brand or marking on the officially approved list of the Exchange and at the following weights:

- Copper: the trading unit is 50,000 pounds or 25 short tons
- Lead and zinc: the trading unit is 60,000 pounds or 30 short tons
- Tin: the trading unit is 5 long tons since it is primarily of non-U.S. origin
- Silver: as in the LME, the trading is at 10,000 troy ounces

These are the major policies and procedures of Comex, and it can be noticed that they are very similar to those at the LME previously described, with changes in terms of time periods for bidding and offers in the Rings and for

hedging facilities, but there are many similarities, essentially.

1.3 Influence of LME and Comex on Price Fluctuations

As was established at the beginning of this chapter, metals which are traded in on Exchanges suffer greater price fluctuations than those which are traded independently. But this statement and the study which proves it is correct, only gives results, not the facts that cause these greater price fluctuations. This section tries to analyze and make inferences according to the current knowledge of policies and procedures in the Exchanges.

The influence of LME and Comex on price fluctuations is due to the following facts:

- The Exchanges have become a way to trade only with the marginal balance of supply and demand. Because they deal in a relatively small sample of copper trade of the world, it is inevitable that the price fluctuations on the Exchanges will be wider than those that would exist if the bulk of copper were dealt through them.
- The Exchange prices represent conditions related to the short-run since the supply and demand hedging facilities apply for three and twelve months. Their prices reflect the world current

events in the economical, political, and financial activities, and of course, the impact on prices of these activities are greater in the short-run than in the long-run.

- The bulk of the trade is made in long-run contracts between producers and consumers, but this long-run contract is tied to LME and Comex prices. Then long-run contracts are tied to short-run volatile prices.
- Hedging facilities and standard contracts have improved a lot of the trading activity, but unfortunately the speculator has gained a lot of ground for his practices too. The amount of speculation in metal increases with the number of hedging operations. The speculator can operate in a rising or falling market and since he is not obliged to pay for the metal, working on credit transactions, his capital requirements are small. The speculation activity makes the fluctuations in prices bigger than they would be without it.
- Both Exchanges permit speculators to act (although indirectly) in the Rings, and this must be due to the system currently used, where the presence of the speculator is indispensable to successful hedging operation. The speculator is always prepared to buy or sell forward contracts at a favorable

price, and no other mechanism has been designed yet to avoid this situation.

Copper producers and consumers, world wide, agree that there is need for a change in the method of copper pricing. Developing countries that produce copper have created CIPEC to counterbalance the strength of the Exchanges. However, at the present, neither the attempt by producers or the attempts by consumers to promote price stability have succeeded. The LME and to a lesser extent, Comex, prices, still determine the world market price for copper and their wide fluctuations have a negative impact on copper demand.

CHAPTER 2

CIPEC: THE INTERGOVERNMENTAL COUNCIL OF COPPER EXPORTING COUNTRIES

The analysis of Chapter 1 concentrated on negative impacts that the London Metal Exchange and the New York Commodity Exchange have on price fluctuations. Unfortunately, there is little that a company or a country alone can do to prevent copper to be marketed and priced in the Exchanges.

The attitude of copper producers in developing countries to this situation has been to create "The Intergovernmental Council of Copper Exporting Countries," well-known as CIPEC.

This chapter is important to the objectives of this thesis because producer countries have attempted to counter-balance copper price fluctuations in the Exchanges by creating CIPEC. The major objective of CIPEC is to stabilize copper prices. The following is a study of CIPEC's major policies, procedures, and market behavior. The last part of the chapter is devoted to analysis of CIPEC's future prospects and its present and future influence on price fluctuations.

2.1 Objectives and Major Reasons to Create CIPEC

In June of 1967, Chile, Peru, Zaire (formerly the Democratic Republic of Congo), and Zambia (formerly Northern Rhodesia) had an intergovernmental conference in Lusaka, capital of Zambia, in order to create CIPEC (from the French Conseil Intergovernmental des Pays Exportateurs de Cuivre).

Its objectives have been defined as:

1) To draft a policy aimed at stabilizing the copper market, which the countries concerned consider vital to their interests as well as to those of the consumer countries.

2) To harmonize the member countries policies towards copper. In this respect CIPEC will act purely in an advisory capacity.

3) To collect data to enable it to make periodic forecasts of the medium and long-term outlook for production and consumption.

The disadvantages of instability in primary product prices are perhaps most noticeable from the point of view of the exporting, developing countries, and in particular, the one crop economies. Heavy fluctuations in the inflow of foreign exchange to these countries have resulted, jeopardizing the long-term plans for economic development and creating frequent crises in the balance of payments.

In the case of the CIPEC members, the dependence on copper is a very heavy one, at least in three of the four participant countries, as is shown in the following table:

Table 2-1

Dependence on Copper Export Earnings
(percentage of total export earnings)

Country	1965	1976 (estimate)
Zambia	91.5	90-95
Chile	70.1	80-85
Zaire	52.5	55-65
Peru	18.6	25-35

The problem of price fluctuations has also been observed in developed countries where the producers as well as the consumers of primary products have argued that frequent, sharp price movements are detrimental to rational long-term planning in industry and to smooth consumer-producer relations. In this case, the most outspoken critics of free pricing and, hence, the most ardent protagonists of price stabilization seem to belong to industries whose products have become increasingly exposed to the risks of substitution.

It can be argued that creation of CIPEC with its major objective of stabilizing the copper market is an advantage for both producers and consumers. CIPEC, in the future, could change to an organization like the International Tin Council, with producer and consumer members.

2.2 Organization of CIPEC

CIPEC is organized according to the following organizations:

- The Conference of Ministers
- The Governing Board
- The Copper Information Bureau
- The Executive Committee

The Conference of Ministers is the main organization of CIPEC and consists of one Minister of Mines (or equivalent) from each country. One vote is cast by each member. Decisions on subjects of major importance must be made by unanimous vote, and a majority is sufficient on minor decisions.

The Governing Board is responsible to, and works under the general direction of, the Conference of Ministers. Two representatives from each member country sit on the board, but each delegation has one vote.

The Copper Information Bureau is responsible for all statistical, technical, and related data and reports of CIPEC. The Bureau acts as a publicity/public relations agency.

The Executive Committee concentrates on financial matters like the raising of funds from world banks and other lending institutions, and the coordination of financial planning with other organizations (like the possibility of OPEC's funding of CIPEC).

2.3 Actions Taken by CIPEC Since Creation

When CIPEC was created in 1967, only Zaire had complete control of its copper industry, and Chile began to have some ownership but not in a significant extent: Peru and Zambia had not yet begun to centralize control of their mining industry. By 1975 Chile and Zambia had already reached 100 percent control over their copper industry also, and Peru had the complete control over commercialization and the big mining activity with the exception of Cuajone and Toquepala open-pit mines run by Southern Peru Copper Corporation (85 percent U.S. interest).

Between 1967 and 1972, most of the CIPEC activities were statistical gathering and political rhetoric.

The first significant action taken by CIPEC was in its Conference of Ministers meeting in Lusaka in June, 1974. Since its creation in 1967 until 1973, the four members held meetings only among themselves; however, at this time they invited, as observers, other producer-countries. At the time the producer-countries were the U.S.A., Canada, Australia, China, Guyana, Mexico, the Philippines, Trinidad, Yugoslavia, Algeria, Japan, Jamaica, Papua New Guinea, Poland, Iran and Malaysia. This list of CIPEC observers included members of the ITC, the IBA, the mercury producers, OPEC, and in addition, other developing copper exporters. The

idea behind this was to close liaison with organizations similar to CIPEC. Future cooperation was agreed upon, but definitive joint policies were not formulated. Aside from the presence of so many observers, the Lusaka Conference had no particular significance.

The major action taken by CIPEC was in its extraordinary conference of November 1974 held in Lima, Peru, where the Conference of Ministers came out with a 10 percent export quota system. The four countries, collectively, vowed to hold monthly copper exports to 90 percent of the average monthly tonnage shipped during the last half of 1974. They aimed to stabilize prices by artificially holding copper off world markets during a time when demand was at a low ebb. It can be remembered that on April 1, 1974, the London copper market hit its all-time high of $1.52 per lb (£1.400 per mt). After 1974, copper prices fell precipitiously.

By the time of the CIPEC's export quota system resolution, the price was around 60 to 65¢ per lb., but the measure was not enough and the price, in December 31, 1974, had fallen to 56.2¢ per lb. (£528 per mt), less than 60 percent of the highest price, and CIPEC's nations took the worst beating of all. One of the reasons, if not the major one, for collapse of the copper price was the world-wide recession and oil crises in 1973-74. Japan sold in the market

300,000 mt of refined copper because its industry could not absorb them. CIPEC put the strong-arm on the Japanese smelters to stop dumping copper on the world markets. How effective this last action was is difficult to tell. Anyway, it is thought things would have been worse without these two decisions made by CIPEC.

In the Conference of Ministers meeting held in Lima, Peru, in November 1975, were added as new members Indonesia (with voting rights) and Australia, Papua New Guinea, and Mauritania as associate members (without votes)

Little of substance came out of the meeting held in Santiago, Chile, in June 1976 except that Chile for the second time demanded that the production/export cutbacks be rescinded, but lost, and quickly backed down on the decision.

2.4 Importance of CIPEC in the Market

CIPEC as an organization cannot be evaluated yet. It is more than fair to talk about CIPEC in terms of its potential rather than its achievements to date.

The importance of CIPEC in the market has changed little, if any, since its creation in 1964 up to 1975. But after the inclusion of the new members (Indonesia, Australia, Papua New Guinea, and Mauritania) its share of the market has increased as follows:

Table 2.2

CIPEC World Market Share

	% Mid-1975		% Sept. 1976	
	Production	Exports	Production	Exports
CIPEC	35	70	42	75
ITC	95	90	95	95

Note: The market share of members of the International Tin Council (ITC) is shown for comparison.
SOURCE: Metal Week Special Report, McGraw-Hill, Inc., September, 1976.

On paper CIPEC is stronger, Whereas, in the past, CIPEC members accounted for approximately 35 percent of the Free World's newly mined copper and controlled, either directly or indirectly, up to 70 percent of the Free World's exports of ore or metal, the respective figures today, with the new members, are 42 percent, and 75 percent. But CIPEC still has little, if any, control over world prices and markets.

Numerically, CIPEC may increase its membership within the next few years and its proportion of copper which is internationally traded. Potential members include countries like Iran with Sar Cheshmeh and other big projects; the Philippines and Mexico, and also South Africa, which in the near future could be ruled by a black government.

For 1978, the estimated capacity of the Free World copper mined is as follows:

TABLE 2-3

Net Increase in Free World Copper Mine Productive Capacity
(thousands of short tons)

Area	Country	Estimated capacity Dec. 31,1978	% est. of capacity	% of Total Exports (1.8 of est. capacity)
	U.S.A.	2,241	24.6	
	Canada	1,080	11.8	
North	Mexico	340	3.4	6.7
America	Other	20	0.2	
	TOTAL	3,681	40.3	
	Chile	1,025	11.2	20.2
South	Peru	480	5.3	9.5
America	Other	15	0.2	
	TOTAL	1,520	16.7	
	Zambia	948	10.4	18.7
	Zaire	875	9.6	17.3
Africa	South Africa	255	2.8	5.0
	South West Africa	65	0.7	
	Other	97	1.1	
	TOTAL	2,240	24.6	
	Philippines	325	3.6	6.5
	Japan	75	0.8	
Asia	Indonesia	75	0.8	1.4
	Iran	164	1.8	3.2
	Other	182	2.0	
	TOTAL	821	9.0	
	Australia	276	3.0	5.4
Oceania	Papua New Guinea	200	2.2	4.0
	TOTAL	476	5.2	
Europe		385	4.2	
Total Free World Capacity		9,123	100.0	

Source: Eight Mineral Cartels, McGraw-Hill, Inc. - March, 1975.

The estimated capacity takes into consideration capital investment, announced and unannounced capacity additions, and industry projections. According to the table, at the end of 1978, CIPEC with its actual members would have 42.5 percent and 76.5 percent of the Free World's estimated capacity and exports, respectively, percentages very similar to those CIPEC has since 1976.

Taking into consideration that countries like Mexico, South Africa, Philippines, and Iran, whose production by 1978 would be 1,084,000 short tons of copper, could join CIPEC, the above figures would change to show a very strong CIPEC with 54.4 percent of the Free World's estimated capacity, and 97.9 percent of the Free World's exports of ore and metal. With these figures, CIPEC would reach its objectives of price and production control of copper in the world market, and this could be as early as 1980.

2.5 Differences Between CIPEC and OPEC

There is no doubt that OPEC influences a great deal in the policies and procedures followed by CIPEC. However, there are great differences between them, the major ones determined by the commodity itself as shown in the following analysis:

- Replacement: Oil in many of its most important outlets when refined as fuel of internal combustion engines

from diesels to jets, as petro-chemical feedstock, and in oil-fired heating applications, is irreplaceable at the present. Copper, on the other hand, can be replaced in many of its major applications by aluminum, lead, zinc, steel or plastics, and the point at which a substitute is preferred depends on the price and/or supply of copper compared with that of competing materials.

- Price elasticity: The price elasticities of copper may be difficult to determine, but they exist due to substitution. In the case of oil, however, there are no alternative fuels waiting to take over its role. Even in cases such as heating, where other fuels can be utilized, often expensive replacement of capital equipment is required to substitute electricity, gas, or coal for fuel oil. Thus, there is virtually no price elasticity for refined oil products at the actual prices, while for copper there are certain price limits beyond which consumption will rapidly fall off.
- Scrap: While oil is consumed and cannot be recovered, there is an increasing market for copper scrap (new and old), and this increases and decreases according to the price and supply of new mined copper. Copper scrap is estimated to account for 40 percent of the world consumption. Scrap recovery accounted

for 46 percent (1.6 million tons) of 1973's U.S. copper supply, or almost as much as U.S. mine production, which was 49 percent of the total (the other 5 percent came from imports).

- Marketing: Oil is extracted and sold in a very highly vertical industry since the companies which are responsible for the extraction of the crude, largely also refine it and sell the finished products, sometimes at both wholesale and retail levels. Then the increase in oil prices is passed on to the market across a range of refined products in a way least likely to damage the overall volume of the companies' business. The copper industry is not integrated as the oil industry (with the exception of the U.S. copper industry) and also copper is marketed in the London Metal Exchange and the New York Commodity Exchange markets, especially the first one, very sensitive to demand, supply, and speculation. Thus, if the producing companies decided to raise prices as a group, the trading on the LME would reflect the views of the market either by following suit, if the price set by CIPEC prove realistic, or by dropping steadily as fabricators moved out of copper.

In the economical and social aspects, there are fundamental differences too, as analyzed below:

Economical aspects:

- In the CIPEC countries, the national economy is almost entirely dependent on a continuing flow of foreign exchange. Copper must be sold on the world's markets in order to produce the money necessary to buy foodstuffs, machinery, and equipment, medical supplies, and aircraft, and all the basic needs that these developing countries cannot produce internally. Also it is very important that such revenues are needed to maintain the industry which produces them, since copper mining is a capital-intensive industry and needs large and regular injections of money to keep it competitive. On the other hand, OPEC countries are very rich; in fact, the biggest problem which faces several of them is what to do with the ever-increasing flow of money which their products generate. For most of the Arab countries, therefore, a temporary reduction in oil output and sales does not worry them.
- Another problem with CIPEC's ability to take any concerted action in the regulation of production is represented by the differences in the cost of producing copper as between each of its member countries. Zambia

and Zaire are in the category of high-cost producers; Chile is considered now an average-cost producer and Peru could be considered between low and average-cost producer. If it is considered that in 1975, the cost of production of copper in the world was between 35 to 55¢ per lb. we can see the problem. These differences are considerably greater than those which exist between the costs of producing oil in the OPEC countries, and such differences make it much more difficult to arrive at any agreement on action to be taken in time of either low or high prices.

Social aspects:

- CIPEC represents countries with large populations of relatively poor people, as compared with OPEC countries with small populations and limited requirements.
- Finally, in CIPEC, there is not the same political unity as in OPEC.

2.6 Future Prospects of CIPEC

CIPEC, as was said before, is going to have a great importance in the international trade of copper in the near future.

CIPEC is not going to be another OPEC, even if its members would like to follow OPEC's example, because of the differences analyzed before between the organizations.

CIPEC in the future has two alternatives; that is, remain as an organization for copper exporting countries only, or change to a model similar to the International Tin Council. Despite which alternative it follows, CIPEC must improve its actual strength following the goals described below in order to get a better market control, if it decides to remain unchanged, or improve its bargaining position with consumer countries if it decides for an organization as the ITC:

-Standardization of production costs (or at least minimize the actual differences) among their members in order to achieve better flexibility in major decisions concerning prices, production, and copper exports.

-It could be its goal in this case to aim at the U.S. copper production costs, and it would be better to aim to a 8 to 12 percent below this cost, since the U.S.A. is a medium-price producer and the biggest producer and consumer of copper in the world. This is not easy to do, but if CIPEC members decide to try it, they can reach it; they can work to reduce their costs, especially in the labor area since the mining workers are the best paid in these developing countries, earning very high wages in comparison with other activities, and also in comparison with the medium- and small-mine industry.

-Try to increase its membership, especially with countries of copper production costs below or similar to U.S.A. costs.

-Since the bulk of the production is sold in long-run contracts, the remaining production could be sold at a fair producers price through a special agency under the CIPEC's control, trying to interest governments of the consumer countries in stock piling.

2.7 Influence of CIPEC on Copper Price Fluctuations

CIPEC has made little, if any, effort to stabilize prices in the world market. Since its creation up to the present, CIPEC has captured an additional 5 percent (from 70 percent in 1967 to 75 percent in 1977) of the total world market exports, and an additional 7 percent (from 35 percent in 1967 to 42 percent in 1977) of the total world production. This is not enough to control prices and markets.

Nevertheless, CIPEC future prospects of stable prices are good, if it is taken into consideration that most of the countries which are recently discovering or putting into production new mines belong to the third world (Iran, Philippines, Mexico, Panama, etc.). Then in the future, it can be expected that the CIPEC members will increase and, consequently, a greater share of the world market exports will be controlled by CIPEC.

In the early 1980s, CIPEC could be controlling 98 percent of the Free World exports and 54 percent of the Free World capacity (see Section 2.4 for further analysis). Then, by 1980 and later years, CIPEC's influence in price determination would be great, relieving most of the problems producers and consumers of copper are confronted with these days. CIPEC would follow a long-run price policy for the bulk of the copper contracts instead of the present short-run price of the Exchanges.

CHAPTER 3

SUBSTITUTION COMMODITIES FOR COPPER IN THE WORLD MARKET

One of the factors playing an important role in the world copper market is the substitution effect. Copper has lost a significant share of its market to other commodities which offered better reliability in terms of price and supply.

In the study of the international copper market, an analysis of past, present, and future substitution trends for copper is essential to the importance of the metal itself, and its future role in the world commodity market.

The copper mining industry is very conscious of this situation and this is one of the major reasons why it is trying to avoid wild copper price fluctuations.

3.1 Uses of Copper

Copper, due to its high conductivity, mechanical strength, corrosion-resistance, malleability, is suitable to be used in those areas of modern technology where growth has been most rapid, that is, electricity generation and distribution, transportation, plumbing, heating, refrigeration, air-conditioning, building and general engineering.

Approximately one-half of copper supplies are used for electrical applications (cables and conduction equipment). Uses of copper in the building industry are also important, as copper metal in the form of wire or sheets or pipe, as bronze (alloyed with tin), or as brass (alloyed with zinc). In general engineering the use of copper is significant; however, it is alloys of this metal which are most commonly used. Alloys of copper are incorporated in tube-in-strip components for heat exchange applications, for example.

As the "incomparable metal", copper's participation in all its traditional uses is limited, theoretically, only by its availability, but it cannot maintain a completely unrivalled position in all its fields and, consequently, copper has had to retreat from some of those uses where price is a major consideration.

3.2 Main Reasons for Substitution

In the case of copper, the main reasons for substitution have been either availability or cost, or a combination of both. In few cases, technical or mechanical factors have replaced it purely.

The principal reasons for copper's substitution are as follows:

- The commodity exchange: Copper is quoted in the LME and Comex, and for this reason, its price fluctuations are higher than any other major metal not traded in

a commodity exchange. (For a further analysis, see Chapter 1).

- The supply factor: When copper becomes scarce, it is very difficult to make the adjustment smoothly during the short-term period of scarcity. The consequence is that fabricators using copper may substitute other materials for copper. Once lost, the market is seldom regained. Thus, uncertainty about supply, whether on account of strikes, transport problems, political troubles, or other causes, has been a factor which worked increasingly against the use of copper in the past few decades.
- Increase of price: In the United States, copper prices after 1950 rose faster than any other major metal with the exception of nickel. This provided consumers with sufficient incentive to substitute cheaper materials or to economize in copper usage.

Coupled with these reasons, it must be taken into consideration that the new metals had certain strengths that made it easier for them to take advantage of the copper's weaknesses. These strengths can be summarized as follows:

- Technology: The techniques of the production and usage of copper were fairly well known by the beginning of the century, leading to some complacence

which found no counterpart in the newer metals, where more thought, money, and energy had to be applied to developing the technologies of these hitherto relatively unknown and unused metals.

- Promotion Techniques: These newer metals, having successfully pioneered the techniques of the production, had to break into markets traditionally held by copper, or to create entirely new uses, and this led to the development of a technical information service and a new type of salesman that was not at that time followed by the older and better established copper industry.
- Marketing: Coupled with this new promotion technique, these newer metals entered the markets freed from the heritage of the older metals quoted on commodity exchanges. The newer metals were able to establish prices and price policies based, on the one hand, on production costs, and on the other, on the economics of the consuming markets rather than on the prices created through the laws of marginal supply and demand.

3.3 Main Substitute Materials for Copper

There were few inroads into copper markets by other metals prior to World War II. The industry became aware of the challenge by other metals during the early 1950's.

By the middle of the decade, it was obvious that copper was losing tonnage to substitutes.

In a survey carried out in 1973-74, it was shown that, of the losses which copper suffered to alternative materials, aluminum accounted for 54 percent, plastics 8 percent, stainless steel 5 percent, and other ferrous metals 18 percent with the remaining 15 percent attributed to design changes so that copper was either reduced in some articles or was no longer a suitable material to use at all, being nothing more than normal technical and technological progress.

Aluminum is by far the most important material competing with copper, so it is going to be analyzed in the next section of this chapter.

The biggest threat to copper by plastics has been within the building industry, and specifically, in plumbing. Already there are on the market plastic cisterns, tape, waste traps, and plastic tubing; most of these products are used only for cold water, but some types can be used for hot water and for heating systems. The plastic industry has as its goal in the near future an all-plastic water system.

The entry of plastics into the engineering field created a great expectation, especially knowing that the main ingredients of the material are coal, oil, air, and lime, which were, in the early stages of development, widely available,

and relatively cheap, whereas today, only the air continues to be free, but there exists the problem of pollution.

Plastics, because of their lighter weight, have always been more expensive per unit of weight than most of the common metals, but due to this characteristic, are often competitive with certain metals for some applications, and in the selection of a material for a specific product the final cost that is important takes into consideration the costs of fabrication, installation, maintenance, and life expectancy.

Statistics indicate that copper has lost 8 percent of its market to plastics, but the trend, according to the actual market conditions, indicates larger losses for the future. Already the number of small individual items in which copper has been replaced by some form of plastic, is enormous even though it does not add up to much in terms of tonnage. Such items include a variety of small engineering components as gear wheels, clock and instrument components, bearings, and even parts of heat exchangers. Plastics have as an advantage over copper their lighter weight, no problems of corrosion, less maintenance, but they cannot compete with copper in life expectancy and heat resistance in general terms.

It is difficult to say what overall effect stainless steel has had on copper usage since, like other newer metals of the modern age, stainless steel's competition with copper

has been more in the promotional and publicity fields, rather than in the technical field.

Stainless steel began to enter the world market in the early years of the present century after researchers in the U.S.A., Germany, and England discovered that iron with 10 percent of chromium produced a metal remarkably resistant to corrosion. After this, it was developed that many other elements may be added to the iron-chromium combination to get steels with special characteristics, the more important being nickel, titanium, molybdenum, and manganese.

For most applications where it does compete with copper, costs are roughly in the same bracket, so the choice rests primarily on the properties of the materials, and in uses which are new to both, on the availability of information and technical assistance provided by their sponsors.

Up to the present, stainless steel has captured only 5 percent of the copper market, specifically in dairy equipment and the brewing industry, but the tonnage which copper has consequently lost has so far been very small. The stainless steel industry claims that in general, its product is stronger, harder, and more heat-resistant than copper, but at the same time, it acknowledges copper's superior conductivity for heat and, of course, electricity, where stainless steel has never offered any threat at all.

3.4 Substitution of Aluminum for Copper

The growth of aluminum production and consumption over the past quarter of this century (1950/1975) has been greater than any other non-ferrous metal. Over the whole period, since 1900, world aluminum consumption has been rising much faster than world copper consumption. For aluminum, the rise has averaged around 9 percent a year, while the corresponding rate for copper was barely 3 percent. But it must be taken into consideration that the growth in aluminum started from a very low base: in the first decade of this century, consumption averaged only 17,000 tons annually, while that of copper was already in the region of 700,000 tons a year.

Aluminum did not overtake copper until the mid-1950's, its great period of growth being during the 1940's, when its uses for military purposes in World War II lifted its annual average consumption to 2.25 times above the 1930's average. Copper consumption also rose relatively fast during the World War II period: on the average, in the decade of the 1940's, it was 45 percent above that of the previous ten years.

The tremendous growth of aluminum production and consumption has been due to its price stability, industry concentration, vertical integration, and narrow band of ore grades variation.

Aluminum is light in weight and moderately strong, and its major applications are in transport systems, in building,

packaging, and in electrical engineering areas which compete with copper, the most important area of substitution being in electrical engineering applications which are the copper's most important outlet, accounting, as said before, for about half of total copper consumption. However, only 10 percent of aluminum production, currently mining about 12 million tons a year, is used for electrical purposes.

In the construction industry, aluminum also competes with copper, but not in a significant way. In fact, in window frames and structures for curtain walling, for which aluminum is emminently suitable, for example, copper would never be used. On the other hand, in plumbing, where copper tubing is firmly entrenched for small-bore water and heating systems, aluminum is rarely used. It is mainly in decorative architectural uses that copper and aluminum are interchangeable. For fully supported roofing aluminum is a direct competition to copper and has the advantage of offering a significant savings in cost. On the other hand, the decorative qualities of copper are considerably greater than those of aluminum.

Non-electrical engineering also offers scope for competition between copper and aluminum. In engineering, however, it is alloys of these metals which are most commonly used. Alloys of copper and aluminum are incorporated in tube-in-strip components for heat exchange applications.

In many heat exchange uses, especially those in which high temperatures are involved, copper alloys are technically superior to those of aluminum, but for very low temperatures, aluminum alloys are the established material.

3.5 Evaluation of Current and Future Substitution of Copper

Even when substitution has affected copper consumption in the last decade, in many ways competition has done the industry a power of good, forcing it to take positive action to expand its market techniques and to develop an outward, and sometimes, aggressive attitude in contrast to its years of deep-rooted conservatism and complacency.

One of the positive actions taken by the copper producers was the creation of the Copper Promotions Producers' Committee (CPPC) in 1960, and since 1965, has been known as CIDEC (from the French, Conseil International pour le Developpement du Cuivre) with the goal "to promote in all countries the use of copper, its alloys, and compounds." Parallel with the setting up of CIDEC came the establishment of the International Copper Research Association (INCRA) which includes the U.S.A. Other research centers exist in Australia,

Canada, and Scandinavia, and all these associations maintain liaison with each other and with the CIDEC centers.

It is difficult to measure the effectiveness of these research centers in cutting substitution of ther metals for copper. However, despite higher prices, the rate of substitution has decreased over the last ten to twelve years.

These development and research centers aimed more to maintain the copper growth rate in those applications in which copper has been traditionally used, such as in the manufacture of electrical cables. Then, the development of a range of new applications has not been significant.

On the other hand, the development and research copper associations do not claim all the credit for cutting substitution because, as a normal process, manufacturers and fabricators began to substitute in those areas where there was small risk of failure or this was less costly than decreasing substitution according to the technical and financial problems to be overcome in order to do it. For example, for the manufacturer of sheet and strip, aluminum can replace copper without much difficulty in the same plant, but the machinery used to produce copper building tubes is not suitable for any of the substitutes, whether plastic, lead, or iron.

At this moment, as they proved to be before, the most urgent concern of the copper organizations and the copper mining industry as a whole, remains the same as ten years

Table 3.1

NET INCREASE IN FREE WORLD COPPER MINE PRODUCTIVE CAPACITY
1975 - 1978
(Thousands of Short Tons)

Area/Country	Mine Production 1972	1973	Estimated 1974	Estimated Capacity Dec. 31, 1974	Additional Capacity Scheduled for Completion During 1975	1976	1977	1978	Total Planned 1975 - 1978	Estimated Capacity Dec. 31, 1978
North America										
United States	1,665	1,718	1,600	1,950	139	59	37	56	291	2,241
Canada	793	898	900	1,020	(11)	3	18	50	60	1,080
Mexico	87	89	95	100	10	40	35	155	240	340
Other	5	7	10	20						20
Total	2,550	2,712	2,605	3,090	138	102	90	261	591	3,681
South America										
Chile	790	811	1,000	1,000			25		25	1,025
Peru	239	243	230	245			170	65	235	480
Other	15	14	15	15						15
Total	1,044	1,068	1,245	1,260			195	65	260	1,520
Africa										
Zambia	791	779	800	900	20	18	10		48	948
Zaire	482	540	560	575		20	95	185	300	875
South Africa	178	194	185	210			33	12	45	255
South West Africa	24	31	35	35		30			30	65
Other	75	83	90	80	17				17	97
Total	1,550	1,627	1,670	1,800	37	68	138	197	440	2,240
Asia										
Philippines	236	244	250	265	15	5	5	35	60	325
Japan	124	101	85	85	(5)	(5)			(10)	75
Indonesia	6	42	85	85		(10)			(10)	75
Iran					4			160	164	164
Other	76	92	110	115	36	31			67	182
Total	442	479	530	550	50	21	5	195	271	821
Oceania										
Australia	206	241	270	260	6	10			16	276
Papua New Guinea	137	202	200	200						200
Total	343	443	470	460	6	10			16	476
Europe	300	334	340	340	5	6	34		45	385
Total Production	6,229	6,663	6,860		236	207	462	718	1,623	
Total Free World Capacity				7,500	7,736	7,943	8,405	9,123		9,123
Percent Increase		7.0	3.0		3.2	2.7	5.8	8.5	5.0	

Source: Eight Mineral Cartels, McGraw-Hill, Inc., March 1975.

ago, that is, to ensure adequate and reasonably priced supplies to present users rather than create new uses for copper The retention of existing markets is a very important point at this time if it is taken into consideration that the free world copper mine production would be increased by 20 percent in 1978, in comparison with the 1974 production. The schedule for completion of additional capacity between 1975 and 1978 leads to a cumulative capacity of 1,620,000 short tons of copper in 1978.

There is no doubt that competition will continue in the future, but it is very difficult, if not impossible, to predict at what levels, as there are now new forces at work affecting both copper and its main competitors.

The U.S. Bureau of Mines has forecast the mineral problems of the mining industry after 1976. Since the United States is the biggest producer and consumer of minerals in the world, it is likely that similar problems will be faced world-wide.

Fig. 3-1 is a resume of the original U.S. Bureau of Mines chart and shows the major problems faced by copper and its main substitutes (plastics are represented by coal and lime) and how these major problems for a specific mineral or metal affect the others. It can be noticed that copper faces two major problems, while aluminum is facing seven major

FIG. 3.1

Mineral Problems - 1976 and Future

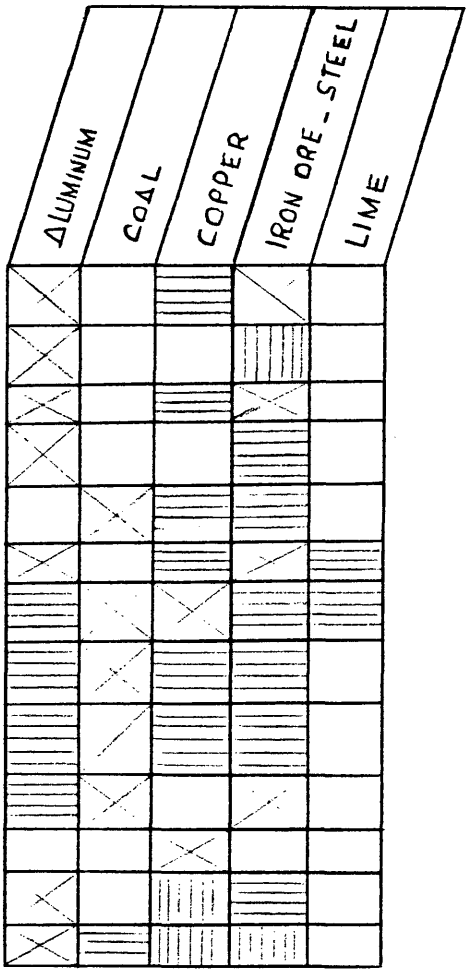
Preliminary Data, September 1976
Bureau of Mines

Major problems from the national viewpoint

Moderate problems from the national viewpoint

Minor or more localized problems

1. U.S. high-grade resource inadequacy, next 4 decades.
2. U.S. reserve inadequacy, next 4 decades.
3. U.S. foreign exchange drain.
4. U.S. vulnerability to foreign disruptions.
5. Mineral industry health and safety problems.
6. Significant energy use.
7. Significant environmental impacts on air.
8. Significant environmental impacts on water.
9. Significant environmental impacts on land.
10. Heavy load in U.S. transport system.
11. Exploration methods inadequacy.
12. U.S. productive capacity inadequacy (mine or well).
13. Inadequate substitutes.



problems, iron ore, steel, and scrap have four; and coal and lime together face five. According to this, it cannot be said that copper is going to have an advantage over its principal substitutes in the future because technology is changing constantly and all depends upon how well these metal industries will overcome their problems and how quickly; but it can be said that the copper industry can see the future with optimism.

The situation of both aluminum and plastics is undergoing, as can be seen in the chart, considerable change. The productive capacity of aluminum, which was in abundant supply up to a year or two ago, could well face a period of relative scarcity, and certainly prospects have diminished for anything like the rapid and immense expansion of capacity which characterized the fifties and sixties.

One of the ingredients in past expansion was the ready availability of cheap power in large quantities in many parts of the world where it was needed. With the energy situation completely changed, the aluminum, plastics, and steel industries face more serious problems in this area than copper. Then, the competition for available energy among all raw material producers will be a feature of the industrial scene from now up to the end of this century.

Table 3.2 shows the heavily disproportionate processing costs incurred by aluminum compared with copper.

Table 3-2

Share of Total Production Costs

	Aluminum	Copper
Extraction*	10	40
Beneficiation	20	10
Reduction	60	10
Refining	--	5
Overhead**	10	35
	100	100

* Ores containing 25% aluminum and 2.5% copper.

** Including transport, royalties, etc.

Source: The Journal of the Institute of Metals, London, April 1966.

Reduction of bauxite to alumina and then to aluminum ingots accounts for 80 percent of total costs while the equivalent processes in the case of copper adsorb only 25 percent of the total production costs. It can be noticed that the above table shows data for April 1966 with ore grades of 25 percent and 2.5 percent for aluminum and copper, respectively. The required electricity in the reduction of alumina was around 14,700 kwh while in the production of copper, was less than 2,000 kwh per ton according to results published by Kaiser Aluminum. If it is taken into consideration that

the U.S. commercial grades in 1966 were below 1.0 percent of copper. These data can be applied to the world average copper grade of the present. Prain maintains that, compared with aluminum, copper requires only about 1/6 of the energy for its production.

Undoubtedly copper is vulnerable to competition from aluminum as its price rises. The producers of copper are well aware of the need to control prices in order to prevent the shift to aluminum, and in the case of the U.S. producers, they are narrowing the gap between aluminum and copper prices (from a difference of 30 5/8 cents/lb a year ago to 7 5/8 cents/lb at the present). Then, the danger to copper has diminished greatly in new fabricating plants which can be set up for this metal instead of using aluminum, if the market can be stabilized, because according to the experience of users over the last decades, even when copper prices are low they do not remain low long enough to influence capital investment decisions.

Another factor that fabricators and manufacturers have to take into consideration is the future behavior of CIPEC and IBA (the International Bauxite Association). No one knows for sure how they are going to behave in the future, but it was analyzed before that CIPEC members have to consider all the constraints suffered by copper while aluminum association members, knowing the lack of adequate substitutes for

aluminum, can take more drastic measures which could affect very deeply the aluminum industry.

To sum up, even when substitution has affected the copper market, the trend is decreasing and the future can be seen with optimism. This is the background that CIPEC members and other copper producers have in mind when they try to avoid a freely-fluctuating market of the LME type and to set a stable copper price.

CHAPTER 4

DETERMINATION OF COPPER PRICE

The function of market price in economics is as a mechanism to match supply and demand. In the copper industry, the determination of the market equilibrium price is complicated by many of the factors already discussed.

1) The pecularities of the functioning of the main metal markets.
2) The influence of CIPEC on price.
3) The complicated inter-relationships of copper with substitutes.

These three factors influence price with different intensity, and although there is no way to quantify their impact in the market equilibrium price, Chapters 1, 2, and 3 have analyzed their positive influence on it.

Apart from these factors, other considerations must be taken into account in the determination of copper price. These considerations are analyzed in the next sections of this chapter.

4.1 Additional Considerations in the Determination of Copper Price

4.1.1. Shortage and Over-Supply of Copper. From 1950 to the present, the copper producing industry with some exceptions has matched or stayed ahead of consumption in order to prevent shortages in the long-run (see Table 4-1). The exceptions were in 1964-67 when the producers could not foresee an upturn in the market, and in 1973 due to political problems in Chile, nationalization of mines in developing countries and lack of confidence in currencies, leading to an inflow of short-term money into commodity investment.

This is a point in favor of the copper producing industry if it is taken into consideration that to open a new mine of considerable size takes between 5 to 15 years as an average from the date of decision to go ahead to the date when production starts, and to extend an existing mine can take two or three years.

In the long run, copper demand and supply come into equilibrium, but in the short run external and internal problems have created shortage and over-supply in the copper industry. Problems which affect the industry are strikes, fuel and power shortages, plant maintenance and repairs, political events and government interferences.

Table 4-1

Free World Statistics of Refined Copper (1950/1975)

Year	Production(1) Refined Copper	Consumption Refined Copper	Refined Copper From Scrap	Copper Scrap Direct use by fabric/manuf.	Total Copper Recovered From Scrap	Total (2) Consumption of Copper	Tot. Scrap over Tot. Consumpt. (%)	LME Price Refined Copper
1950	2,860.0	2,613.5						178.8
1951	2,854.5	2,751.0						220.36
1952	2,810.3	2,806.1						259.35
1953	2,955.3	2,657.6						251.15
1954	3,022.2	2,864.3						248.59
1955	3,319.2	3,249.9						351.42
1956	3,527.5	3,318.6	571.9	1,439.7	2,011.6	4,758.3	42.3	328.92
1957	3,515.8	3,324.7	513.8	1,357.4	1,871.2	4,682.1	40.0	219.49
1958	3,428.1	3,347.6	527.6	1,318.2	1,845.8	4,665.8	39.6	197.38
1959	3,602.9	3,541.2	592.6	1,513.8	2,106.4	5,055.0	41.7	237.76
1960	4,198.7	3,828.4	678.4	1,511.4	2,189.8	5,339.8	41.0	245.96
1961	4,297.7	4,096.8	672.1	1,559.4	2,231.5	5,656.2	39.5	229.57
1962	4,393.8	4,105.0	692.5	1,615.7	2,308.2	5,720.7	40.3	233.98
1963	4,463.1	4,365.3	675.5	1,734.2	2,409.7	6,099.5	39.5	234.27
1964	4,792.6	4,855.0	772.6	1,940.5	2,713.1	6,795.5	39.9	351.07
1965	5,101.1	4,985.6	899.6	2,036.9	2,936.5	7,022.5	41.8	468.07
1966	5,168.6	5,215.5	989.7	2,073.5	3,063.2	7,289.0	42.0	555.00
1967	4,776.7	4,984.7	904.7	1,935.7	2,840.4	6,830.4	41.6	418.04
1968	5,394.8	5,179.6	1,018.8	2,109.8	3,128.6	7,289.4	42.9	525.30
1969	5,877.1	5,745.6	1,113.0	2,346.8	3,459.8	8,092.4	42.8	620.75
1970	6,163.4	5,835.4	1,138.0	2,156.0	3,294.0	9,129.4	36.1	589.45
1971	5,837.1	5,733.2	916.7	2,222.3	3,139.0	7,955.5	39.5	444.36
1972	6,374.4	6,265.1	947.0	2,297.6	3,244.6	8,562.7	37.9	427.82
1973	6,680.5	6,947.7	1,029.7	2,600.8	3,630.5	9,548.5	38.0	727.10
1974	6,939.8	6,486.2	1,123.2	2,403.8	3,527.0	8,890.0	40.0	877.63
1975	6,266.5	5,488.8	845.2	1,951.3	2,796.5	7,440.1	38.0	556.55

(1) Includes production of refined copper from scrap.
(2) Includes Consumption-Refined Copper plus Copper Scrap-Direct Use by Fabric/Manufact.

Source: Metal Statistics, Frankfurt AM (1947-1956, 1956-1965, 1965-1975).

Whenever production and stocks of the metal are not large enough to fill demand, the consequent shortage can send prices soaring due to the sensitive market system in which copper operates (see Chapter 1 for a further analysis). When an oversupply situation exists, it is difficult to cut back production in order to avoid a decline in price. This is particularly relevant to the developing producer countries, whose economies depend heavily on the copper trading. The U.S.A. is facing this problem right now; U.S. producers, due to over-supply, are trimming production schedules (price was reduced from 74 5/8 to 60 5/8 cents per pound in 6 months) while such underdeveloped nations as Chile, Zambia, and Zaire are producing copper in substantial amounts, despite slack demand, in hopes of increasing foreign-exchange earnings.

Other problems that must be considered, and which affect the solution of shortages and over-supply in the same measure, include the great distance between mine and market which some of the exporting countries have to content with; often it takes as long as three months to empty or fill a pipeline.

It is difficult to solve short-run shortages in the industry because normal working conditions are near 100 percent capacity operations and it is difficult to expand production beyond it.

4.1.2 U.S.A. Labor Contracts. Price variations in the short-run are also influenced by renegotiation of labor contracts in the U.S.A. which can cause production decline every three years because of strikes. This year, the U.S. copper industry had hoped to reduce over-size industry stocks as a result of a strike by the 45,000 copper workers after June 30, 1977. However, a lengthy work stoppage never materialized. Kennecott raced to a settlement, drawing rage from others in the industry, the majority of whom quickly followed suit. A copper analyst in an interview (Denver Post, New York Times, Sept. 12, 1977) said "Copper buyers had anticipated a long strike. When the strikes were settled much faster than expected, there was a hunk of copper looking for a home. I think everyone is pretty well provided with copper for three or four months." Current depressed copper prices prove this to be true.

4.1.3. Capital Cost of Mining. The relatively new problem facing the copper industry today is finding new sources of capital to develop known sources of supply. The capital cost of mining has escalated enormously over the past ten to twenty years. In order to meet projected consumption rates, the discovery rate of copper each year must be equivalent to 1.4 billion tons of ore at 0.5 percent in order to merely maintain reserves (Copper - R. Prain, 1975).

In order to develop these new reserves, an annual investment of the order of $1 billion annually will be necessary. In the 20 years between 1951 and 1970, for example, the average capital cost of creating a short ton of new annual capacity more than doubled; it increased in fact from $1,300 per short ton of electrolytic copper to about $3,000. In the case of extensions of existing mines, there was a corresponding increase up to about $2,000 per short ton by 1970 (Copper - Prain, 1975). In the case of Cuajone, the open-pit mine run by Southern Peru Copper Corporation in Southern Peru involved an investment of $725 million to produce 175,000 short tons of electrolytic copper. This is equal to $4,143 per ton of capacity added to the Toquepala-Cuajone-Ilo production system. The investment, which includes loan interest and working capital, was large because of extensive infrastructure needs.

4.1.4 Cost of Production. The relationship between mining costs and copper price has been deeply studied for many years. It is impossible to relate closely the price of copper to the cost of production. In 1975, costs of production ranged from 35¢/lb to as high as $1/lb in the industry world-wide. In a tight market, price is likely to be determined by the highest cost producers. In a slack market, the price leaders are likely to be the low cost producers. The wide-range between the low cost and the high cost producers

makes prediction of actual price very difficult. Average cost of producing the world's competitive copper was 13¢/lb in 1952, 20 1/2¢ in 1960, 32¢ in 1970 (Copper - Prain, 1975). Today's average cost could be between 60¢ and 70¢/lb.

The costs of production are so wide because the mining industry is widely spread throughout the world. It is not very much vertically integrated (exception made of the U.S.), and uses different systems of production; the copper grades also vary widely.

All these factors described above influence the price fluctuations of copper in one way or another. Another factor that has to be taken into consideration is scrap, and it is analyzed in the following section.

4.2 Copper Scrap Considerations

Copper is frequently spoken of as the indestructible metal, because it does not rust and corrode like iron. Then, in attempting any sort of perspective of world copper production and consumption, one must look beyond the statistics of refined copper as a source of supply and study also the secondary copper or copper scrap in order to do a realistic analysis.

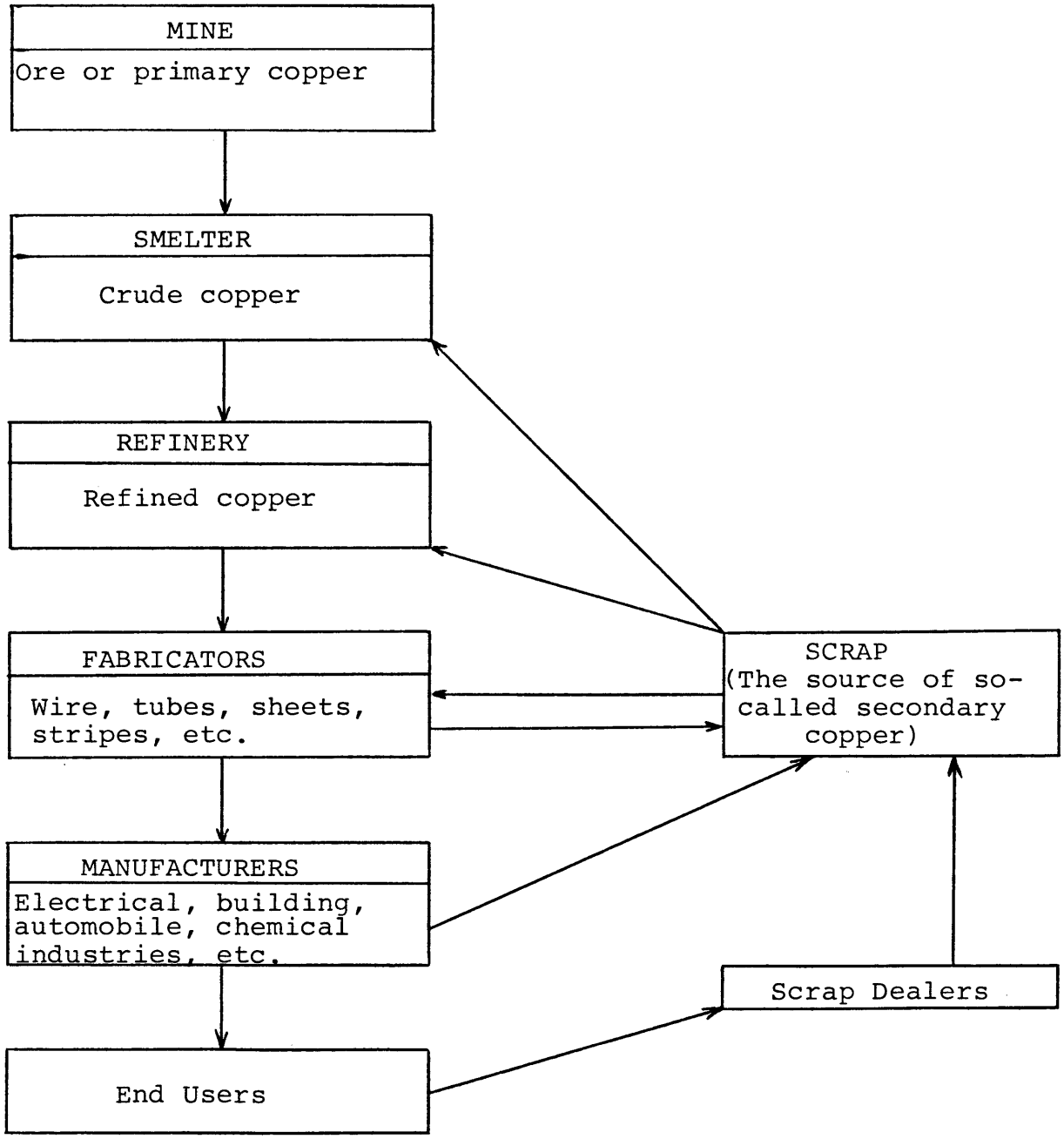
Secondary copper or copper scrap is defined as that copper metal reclaimed from scrap returned by industry to be retreated and refashioned into marketable forms.

This secondary copper is classified in two categories:

- New scrap: This arises in many forms, as shavings or swarf, as ends cut off the lengths of cable, and as a variety of other discards or rejects. Fabricators and manufacturers are the principal suppliers of this so-called new scrap.
- Old scrap: This is material salvaged from obsolete equipment and machines sold before to end users. Organizations like railways and telecommunications networks are big producers of old scrap. Also old automobiles and buildings pulled down for re-development yield considerable quantities of copper material.

How this copper scrap (new and old) is collected and recycled is shown in Fig. 4.1 on the following page. The better qualities of industrial scrap are often used after re-melting by brass-makers and other non-electrical industries as a raw material. Lower quality scrap is returned to refiners for secondary processing. Large amounts of industrial scrap generated by building and automobile industries are sold to scrap dealers, and find their way to the refineries for conversion into fire-refined or electrolytic copper. Much old scrap, which may be contaminated with every sort of metal, eventually re-emerges from refiners in the form of ingots which are used primarily for making copper alloys.

Fig. 4-1. Flow of Secondary Copper in the Copper Industry



Most of the fabricators and manufacturers have contracts with refiners in order to re-process the new scrap and, in this way, have an additional source of supply to supplement their producer contracts. Some manufacturers and main distributors go even further and sell their products with trade of the old item.

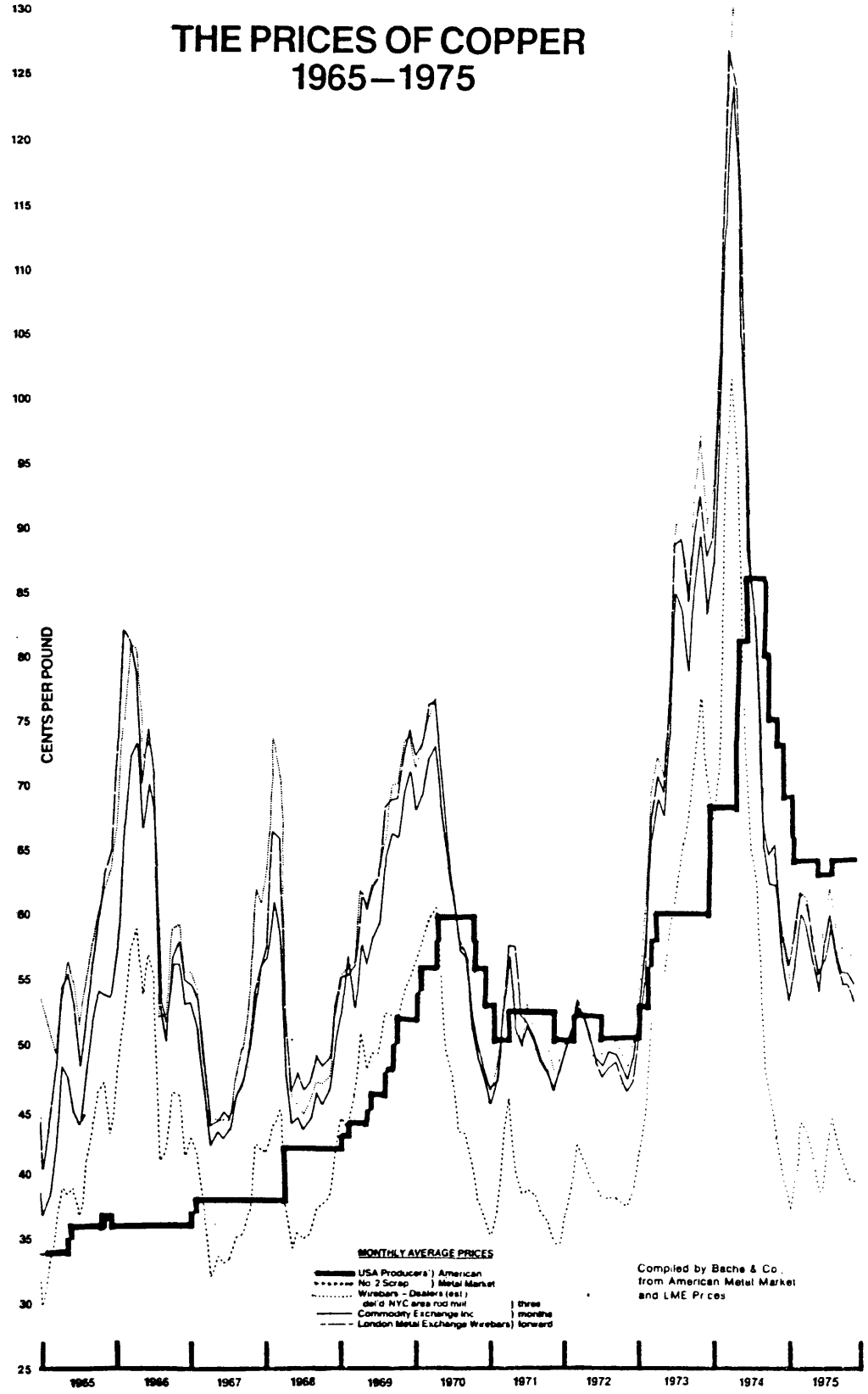
As compared to the trade in primary copper, there is very little movement of secondary copper across international boundaries, and to some extent, there is an outright prohibition of scrap trade. The object of these restrictions is to reduce the need to import primary refined, which is often expensive relative to secondary, and thus to some extent to encourage the expansion of the industry producing secondary copper. The largest importer of scrap of all the major copper consumers is Japan, which gets much of this material from North America.

Chapman in his "Energy Conservation and Re-cycling of Copper and Aluminum" (Metals and Minerals, June 1974) has calculated that the efficiency of recovery of new scrap is 85 percent in the U.S. and 84 percent in the United Kingdom, while for old scrap, it is 45 percent in the U.S. and 30 percent in the U.K. He has further calculated that in the U.S.A. and U.K., if 100 percent efficiency were achieved in collection and treatment, scrap could supply 75 percent of consumption.

The volume of recycling copper scrap is remarkably constant at 40 percent of total consumption as it was calculated for the period 1956-1975 in Table 4-1, with a minimum of 38 percent in 1975 and a maximum of 42.9 percent in 1968. Analyzing Table 4-1, it can be noticed that, of the total scrap that is recovered every year, about 30 percent returns to the market as refined copper and in this way it accounts for about 18 percent of total refinery production. The other 70 percent is used directly by fabricators and manufacturers. Since these percentages have not changed substantially over the last 25 years, they are an interesting statistic which tends to help the forecasting of future supply and demand.

The prices of scrap normally follow the levels at which virgin metal is sold as demonstrated in Fig. 4.2 for the years 1965 to 1975. When copper prices fall, scrap prices usually follow and vice versa. Then the supply of scrap is also subject to the fluctuations of the markets for virgin and refined copper. When in a rising market the price of copper is abnormally high, then manufacturers may switch to secondary ingot copper to some extent, because there is a limit to the quantity of scrap that can be used and because price rises for scrap tend not to be as great as the rises for refined copper. But such secondary competition, if it

FIG. 4-2


THE PRICES OF COPPER
1965–1975
CENTS PER POUND
130
125
120
115
110
105
100
95
90
85
80
75
70
65
60
55
50
45
40
35
30
25
1965
1966
1967
1968
1969
1970
1971
1972
1973
1974
1975
MONTHLY AVERAGE PRICES
USA Producers') American
No 2 Scrap) Metal Market
Wirebars - Dealers (est.)
del'd NYC area rod mill) three
Commodity Exchange Inc) months
London Metal Exchange Wirebars) forward
Compiled by Bache & Co.
from American Metal Market
and LME Prices

may be called competition, never stops the wild upward gyrations in the copper market. The latter always brings its own downfall because virgin production is stimulated so greatly that an overproduction of primary always results, as shown for the years 1974-75 in Fig. 4.2.

The preceeding arguments lead to the conclusion that in a normal, more rising market, secondary copper will have practically no effect on market price for copper. In abnormal times, or in a falling market, the effect of secondary is small compared to total refinery output which sets the price. The secondary market has so little effect that it is a distortion to charge scrap with the whole or part of a price decline. In the future, secondary copper may influence prices when its share of the market has increased as a result of more efficient scrap collection. Another factor that may increase the importance of scrap is international trading in scrap by relaxation of controls on exports of scrap by major copper consuming and scrap producing countries. Thus, scrap could make a greater contribution to the total market outlook for copper in two main ways: by increasing the supply and by acting as a restraining influence on prices.

4.3 Summary and Future Prospects

The determination of the copper market equilibrium price is complicated by all those factors already discussed through chapters 1 to 4 and which are listed below:

- Commodity exchange systems
- CIPEC price influences
- Substitution effects
- Shortages and over-supply problems
- U.S. labor contract renegotiations for copper
- Increasing capital cost of mining
- Escalating cost of production
- Copper scrap considerations

It is very difficult to say to what degree they affect price. With the exception of CIPEC and copper scrap considerations, which up to the present appear to have little, if any, influence in price, the other factors have a positive influence on it.

On the other hand, wild price fluctuations have led to the creation of CIPEC and to the increased reliance of some consumers on copper scrap. It is difficult to foresee how these two factors could lead to easier price determinations. The tendency would seem to be for CIPEC to stabilize prices and then, therefore, eliminate some uncertainty and make it easier to determine an expected price. Copper scrap

could increase its share of the market improving its currently recycled technology. A positive measure, too, would be the opening of its current barriers of international trade. In this way, copper scrap could have a positive influence on copper prices.

Presently and in the near future, the other factors will continue with their influence in copper price determination. The world's supplies of new copper will continue to be sold at prices fixed individually by producers but always related to a commodity exchange, and for practical purposes, this means the LME or Comex quotations.

CHAPTER 5

FURTHER PROCESSING OF COPPER AND ITS IMPLICATIONS IN DEVELOPING COUNTRIES

Traditionally and logically, most copper fabricating and nearly all manufacturing involving the use of copper have so far been carried out in west (including Japan) industrialized countries. Nevertheless, there has been a growing trend for developing countries, especially CIPEC countries, to interest themselves in copper fabrication. The origin of this trend is found in the claim of developing countries for a new international economic order.

This chapter studies and analyzes the advantages and disadvantages further processing would have for developing countries and what would be the influence of this action on the copper market conditions.

5.1 Scope of the Study and Some Basic Definitions

The analysis will consider only developing countries with a significant copper production and for this purpose, specifically CIPEC member countries, that is Chile, Peru, Zaire, and Zambia.

It is possible to study the organization of the copper industry according to the processing steps as follows:

- mining
- milling
- smelting
- refining
- fabricating
- manufacturing (end user)

The production of copper moves from the mining stage, to stages where the ore is "milled" (product: concentrates); "smelted" (product: blister) and refined (product: electrolytic copper), right through to a stage where the output of the refinery is turned by a fabricator into what are known as semifabricates or semis. The form for these semis is sheets, tubes, rods, and wires. The last step is to turn the semis into such things as components for plumbing and heat installations, where these components (such as cables, fixtures, etc.) are called "end uses."

By "further processing" is understood in this analysis the fabricating step alone without considering the manufacturing activity.

Fabricators in developed countries buy their copper in raw or primary form as wirebars, cathodes, ingots, etc., products which are current output of developing copper producer countries. The major copper producers and consumers in the world are shown in Table 5.2.

5.2 Advantages and Disadvantages of Further Processing

The advantages and disadvantages of further processing are referred to export business, because currently CIPEC

countries have some fabricating plants (most of them wire mills) which supply the internal market (electrical cable industry), which of course is not significant in comparison with the copper exports. The consumption of refined copper in the internal markets is as follows for 1974:

Table 5.1

CIPEC: Production and Consumption of Copper
(figures in mt.)

Country	Mine	Smelter	Refinery	Refined Consumption
Chile	880,000	720,000	550,000	35,000
Peru	190,000	180,000	35,000	12,000
Zambia	700,000	690,000	650,000	4,000
Zaire	490,000	480,000	220,000	3,000
	2,260,000	2,070,000	1,455,000	54,000

Source: Eight Mineral Cartels, McGraw-Hill, Inc., 1975.

5.2.1 Advantages of Further Processing

There are at least five major advantages to developing countries of further processing of copper ores beyond the refining steps.

- Attraction of foreign capital and technology: Copper developing countries with the attraction of foreign capital would improve their balance of payments conditions and highly skilled personnel would be molded to fill the requirements of fabricating plant jobs.

Table 5.2

Mine Production and Refined Consumption* (1975)

Major Producer	Mine Production (1975)	Major Free World Consumers	Refined Consumption (1975)	Percentage of Total Free World Consumption	Growth Rate Consumption (1965-1974)
U.S.	1,411	U.S.A.	1,540	26.4	.9
Chile	913	Japan	889	15.2	8.4
Canada	798	Germany F.R.	683	11.7	3.5
Zambia	746	U.K.	497	8.5	-2.9
Zaire	507	France	402	6.9	4.1
Philippines	249	Italy	303	5.2	5.4
Australia	230	Canada	215	3.7	2.9
S. Africa	197	Belgium	192	3.3	4.4
Peru (1)	195	Brazil	171	2.9	20.3
Papua New Guinea	190	Australia	113	1.9	2.3
		Sweden	104	1.8	1.4
		Mexico	78	1.3	6.9

* Production and consumption in thousands of tons.
(1) Since 1977, its mine production will increase to 450,000/yr. due to Cuajone and Cerro Verde open pit mines.

Source: Various publications (World Bureau of Metal Statistics, Metallgesellschaft, and others).

Table 5-3

Summary of Tariffs on Copper Metal and Semi Manufacturers (in Percents)

Country	Duty (%) Copper Metal	"semis"	Tariffs
E.E.C	0	8	
Japan	8.5	15	
U.S.*	3[a]	2-4[b]	[a]-B substantial part of imports would be suspended from duties.
			[b]-Rods, bars, plates, sheets, relatively unprocessed and seamless pipes and tubes. These items, together with copper wires, account for 90 percent of U.S. imports of semis.
		7[d]	[d]-Wire, other than nickel silver
		8-13[e]	[e]-Other items excluding nickel silver products.
Denmark	0	0[a]	[a]-Rolled and extruded products, of which the greatest cross-sectional dimension does not exceed 20 mm coiled
		4-5[b]	[b]-Other semi-manufacturers
Finland	0	2-3[a]	[a]-Bars, rods, sections, and wire
		4.5-5[b]	[b]-Plates, sheets, strip, tubes, and pipes
Norway	0	0-0.3[a]	[a]-Semi manufactures other than tubes and pipes.
		5[b]	[b]-Tubes and pipes
Sweden	0	3[a]	[a]-All semi manufactures
Switzerland	0.1	1-4[b]	[b]-Some sub-items are subject to a duty of 5-6 percent
Austria	0	8[a]	[a]-Unworked bars, rods, sections, plates, sheets and strip. Wire of 0.25 mm or more.
		9-10[b]	[b]-Worked bars, rods, sections, plates, sheet, and strip.
		12[d]	[d]-Unworked tubes and pipes and blanks therefor
		15[e]	[e]-Worked tubes and pipes

Canada*	0[a]	5[b]	[a]-Unalloyed copper [b]-Bars, rods, plates, sheets, tubes
	5[d]	10[e]	[d]-Brass [e]-Electric wire

* The U.S. and Canadian tariffs are F.O.B. duties.

SOURCE: Constructed from GATT Document COM.TD/71, 19 February, 1970 (Import Duties on Copper and Copper Products).

- Industry linkages: Spin-offs or complementary production of supplies for fabricating plants would be set up increasing the whole country's industrial growth.

- Employment: One of the biggest problems faced by developing countries is unemployment. This could relieve it with the jobs created in a direct and indirect way.

- Stability of export earnings: The instability of prices of primary products is well known and how they affect the economic planning of developing countries. Semi-fabricated products have prices relatively more stable than primary products.

- Foreign exchange earnings: Up-grading their copper exports to fabricated forms, these countries could maximize foreign exchange earnings, at the same time relieving their import payments in hard currencies for semi-fabricated products.

5.2.2 Disadvantages of Further Processing

There are some economic and instutional disadvantages to further processing in developing countries:

- Trade barriers: trade barriers, in particular tariffs,are imposed on the import of semi-fabricates

in most of the developed countries, while there are not import duties on ores, concentrates, or refined copper, with the exception of Japan and United Kingdom (see Table 5-3). The E.E.C. common external tariff places a duty of 8 percent on most semi-fabricates. In Japan most wrought copper products carry a duty of 8.5 percent with a duty of 15 percent on most other items. The U.S. tariff includes a large number of sub-items relating to copper products, and most of these carry both a specific and an ad-valorem duty which varies between 5 and 10 percent.

- Transportation costs: semi-fabricated products will cost more to ship than primary copper. The main reason for this is that freights are on an ad-valorem rather than a weight basis. Other minor factors consider possible greater difficulty in handling, greater care, and cost required in packaging, transport, insurance, and shipping.

- Variety of products: There are thousands of different semi-fabricated products made of copper. For example, tubes, sheets, rods, wires, etc. Tube has to be made in a variety of diameters, thicknesses, gauges, and lengths, and with sheets, wires and cables, exist the same problem. Also these products may have to

be made in either pure copper or in alloy, which in itself raises the question of the procurement of the alloying elements.

- Pipeline and consignment stocks: To finance a pipeline which has to deal with a great variety of products of many different sizes, shapes, and gauges requires very significant amounts of money. Besides, the financial problem increases if it is taken into consideration that a multiplicy of different consignment stocks at the consuming ends must be maintained in order to make a quick delivery as required by the manufacturers.

- Finance of fabricating plants: Producer countries have to face a very big problem to finance fabrication projects because, poor countries as they are, they would have to rely on external finance funds, and developed countries, such as Japan and Germany, have demonstrated their willingness to make capital available only in return for intermediate products, namely concentrates, blister, or refined copper, and not for fabricated products.

- Technology: Copper favricating is a highly competitive business, and even if a producing country could

get the current knowledge to run such a plant, it must keep up to date with continually changing customer requirements, which necessitate modernizing plant and equipment with considerably greater frequency than for the smelting and refining steps.

- Quality change: While the quality of primary products tends to remain relatively constant, the quality of semi-fabricated products has risen substantially through the years.

5.3 Situations and Essential Ingredients to Overcome Obstacles

Actually, developing countries do not have any advantage to up-grade the value of their exports from refined copper to semi-fabricated products. However, it is possible that some of the disadvantages of producer countries in the area of fabrication can be eliminated through the cooperation of developed countries. One of the best ways to close the gap between the industrialized and the non-industrialized countries would be for the first ones to make available technology. In this way, non-industrialized countries could develop faster, increasing their level of industrialization. It may also be possible for developing countries to force the industrialized world to supply technology because of their advantages in the area of primary resources combined with cartel measures

like CIPEC. Table 5-4 shows the Free World copper resources for the future. Developed countries will rely more on developing countries for their needs of copper.

Disadvantages such as barriers to trade, transportation costs, and the need for stocks to fill the pipeline can be overcome by negotiation at government levels. This requires changes in policies affecting import duties, freight charges, and maintenance of national stockpiles of the most used semi-fabricated products. This would decrease copper price fluctuations, and such stabilization would relieve one of the biggest problems in the copper industry. On the other hand, problems like variety of products, finance of fabricating plants, technology, and quality change would be more difficult to overcome due to the following reasons:

-Worldwide competition in this industry pressures the multinational corporations toward the development of technologies with increased productivity in order to make temporary extra profits. The use of continuous casting demonstrates the international character of these developments. In continuous casting, refining, and fabricating are combined into one process, starting directly from the cathode and supressing the stage of the wirebar. The cathode copper is melted directly into the required shapes. New conventional plants cannot compete with continuous

Table 5.4

Free World Copper Resources
(million short tons of copper)

	Reserves	Other*	Total
North America:			
U.S.A.	90	320	410
Canada	40	130	170
Other	20	30	50
Total	150	480	630
South America:			
Chile	90	130	220
Peru	30	40	70
Other	10	70	80
Total	130	240	370
Europe: Total	20	40	60
Oceania: Total	20	60	80
Asia: Total	30	170	200
Sea nodules	--	400	400
Africa:			
Zaire	20	30	50
Zambia	30	70	100
Other	10	20	30
Total	60	120	180
World Total	410	1,510	1,820

* Includes undiscovered (hypothetical and speculative) deposits.

Source: Mineral Facts and Problems, U.S. Bureau of Mines, 1977.

casting plants in terms of price per unit of output and general quality of products produced. Developing countries cannot assimilate in a reasonable time these new technologies due to lack of capital and skilled personnel.

-The political instability in developing countries also inhibits the development of down-stream integrated processing. The industrialized world would not look favorably on such further processing because they would be more dependent than ever on the developing countries for copper supplies needed by manufacturers.'

-The evolving pattern of trade is built around long-term contracts. Japan and Germany, for example, have signed contracts with firms in Canada, Australia, Indonesia, Papua New Guinea, Chile, Zaire, etc., contracts which run up to twenty years in order to get concentrates, blister, or refined copper.

5.4 Conclusions

Although some of the difficulties mentioned might be overcome in the long-run, it is unlikely that treating in semi-fabricated products will change significantly. CIPEC countries will find difficulty in selling processed output in competition with established copper-based fabricators in Europe, Japan, and the U.S.A. The best they can do is

to develop agreements with fabricators in the industrialized countries in order to import technology to run fabrication plants. The output of these fabricating plants could be sold to other non-copper producing developing countries. These agreements on contracts can be made to create mixed companies between governments and foreign enterprises (this approach would be the most reasonable, at least in the beginning), or plainly, buying the know-how and technology, hiring the foreign enterprises as consultant firms.

Most of the trading of semi-fabricated products for copper producer countries would be on limited quantities of limited variety of products. In the case of Chile and Peru, they would have very good prospects to sell their products to countries like Venezuela, Colombia, Ecuador, and Bolivia. On the other hand, Zambia and Zaire could do the same thing with their country-neighbors on the African Continent.

CHAPTER 6

DEVELOPMENT OF COPPER PRICES AND THEIR FORECASTING

6.1 Historical Development of Copper Prices

The price of copper is related to major national and international events and two major influences can be identified (see Fig. 6-1):

1) Wars which produce an upward swing in copper price, and
2) Economic recessions which result in a decline in copper prices.

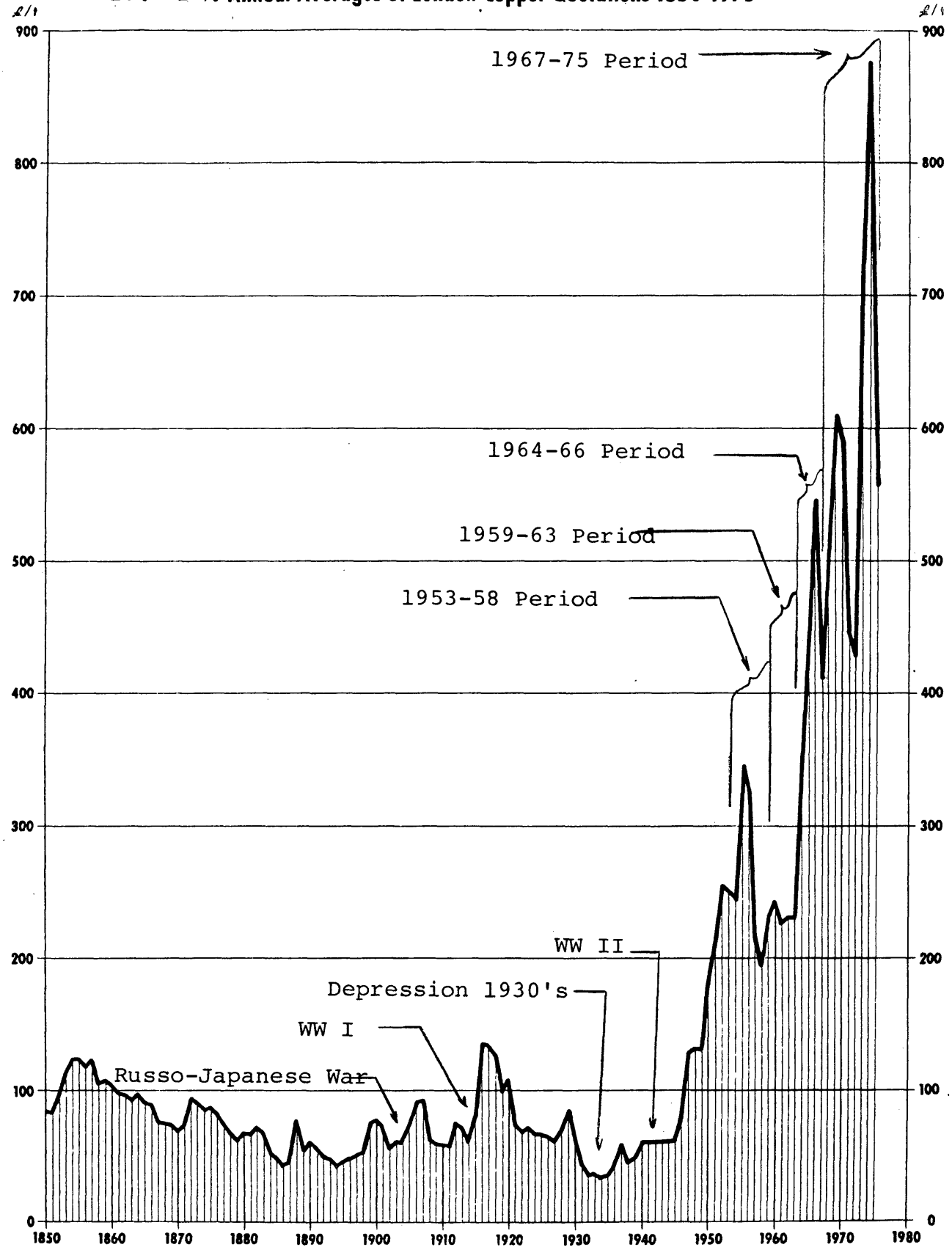
A number of examples can be given that caused an increase in copper price since 1900 through the 1950s:

-The Russian-Japanese War in 1905 took the price from a minimum of £70 to a maximum of £110

-The First World War took the price from a minimum of £50 to a maximum of more than £150.

-The Second World War would have had similar effects if the British and the American governments had not taken very restrictive measures, including the total suspension of LME trading.

FIG. 2 .. **Annual Averages of London Copper Quotations 1850-1975**



Source: Metal Statistics 1965/75 - Frankfurt ΔM, May 1976

From Manuel E. Alegre (1977) Marketing of Copper in the World and Its Implications (Thesis submitted to the Colorado School of Mines).

In the future, the impact of wars may not be as strong on copper price because copper is no longer as strategic a military material as in the past.

The Depression of the 1930s is the most typical example of an economic recession during the 1900-1950 period. The copper price dropped to its all time low of £25 a ton and some of the world's largest mines had to be closed down.

Since 1953 to the present the following periods can be identified (see Fig. 6-1):

-1953-58 Period: In August 1953 the trading in copper was re-opened in the LME and Comex. Price declined from £252 to £214, but it recovered to an average of £233. For the next three years, it continued to rise steadily due to a period of general prosperity (post-war reconstruction) and also due to the Korean War. Toward the middle of 1956 there began a steady decline in prices due to a stabilized consumption and an increase in supply. The mining industry had to cut production in these times of over-supply. Then during years 1953 to 1958, copper prices fluctuated sharply.

-1959-63 Period: This was a period of moderate fluctuations.

-1964-66 Period: A sharp increase in demand occurring toward the end of 1963 put an end to this type of stabilization. The market was divided: the producers of Chile, Zaire, and Zambia decided to continue selling

at the same price while LME prices rose steeply; a sharp difference remained between these two quotations. By April 1966, the producer's price was abandoned by Chile, Zaire, and Zambia. The LME price declined from £555 to £418.

-1967-75 Period: In 1967, the effect on copper prices of the Zambia-Rhodesia confrontation was another sharp increase in prices, which remained up to mid-1969. By the mid-1970s, the recession brought a decline in prices up to 1973, when an increased demand brought the copper price to its highest price in 1974. Since then up to the present, the market has been depressed.

6.2 Different Methods to Forecast Copper Prices

The challenges presented by the complex relationship between copper costs, grade, price, capacity, substitution, and scrap effects and political affairs, have been long recognized in the industry and many attempts have been made to define this relationship more precisely and apply any lessons which may be learned to a greater understanding of the various trends. To the present time, no method or technique has been developed to forecast copper prices with good precision. Nevertheless, any time a new project

or significant capacity expansion is planned, price forecasts are made for the evaluation of profitability.

The most common methods used by the industry or developed by economists and analysts are as follows:

- Econometric models
- The Notman formula
- Linear regression technique
- Future value of prices according to an annual average growth.

The author of this thesis has developed a method to forecast copper prices too, which is explained and applied in the last part of this chapter.

6.2.1. Econometric Models:

Many attempts have been made to forecast the price of copper applying mathematical models but very limited success has been obtained. Econometric models for copper and commodities in general have to deal with such kinds of problems that practically nullify their effectiveness, as Ferdinand Banks acknowledges in his book "The World Copper Market" (Ballinger Publishing Co., 1974):

> "On the basis of evidence submitted by most econometricians who have worked with commodity models, it seems unlikely that we are going to see, in the near future, econometric models. There are several reasons for this. The first, quite obviously, is the absence of data-collecting facilities for commodities comparable to those available for aggregate economic variables such as income, consumption, etc. In conjunction with this, there is a shortage of variables, which means that data-collecting facilities

> "should in addition to such things as price and output, be obtaining information on costs, capacity, and other variables of a microeconomic nature: variables having to do with the installations where these commodities are produced. This is asking a great deal. Finally, there is poverty of forms into which the basic supply-demand relationship can be worked."

For the reasons named above, when it comes to price predictions for most raw materials, copper included, econometrics acting alone is not the trend of the future but the trend of the past.

6.2.2. The Notman Formula:

One of the best known theories of this subject was that developed by Arthur Notman, a well-known American mining economist, more than 40 years ago. According to his studies, the average net profit after income tax of copper mining companies quoted on Comex tended to run 25 percent of the average price of copper. When profit rates are below 25 percent, this causes investment in new copper mining companies to fall and after a time, the metal would be in a shortage and the price would rise until the position adjusted itself. On the other hand, a rate above 25 percent resulted, after a time, in a surplus of copper and consequently, a lower price until the position was restored. Notman calculated that the ratio of price to cost would be 12:7. This formula is verified by empirical data over several periods subsequent to Norman's analysis. Unfortunately, this relationship does

not apply today because of new factors affecting the market. These new factors appeared after the 1960s and are the result of escalating costs, inflationary pressure, and the change of ownership of productive capacities from transnationals to the governments of developing countries.

6.2.3. Linear Regression Technique:

Many companies use the linear regression technique to forecast future copper prices, but it is well known that this technique is more valuable in the short run than in the long run because it takes into consideration past data without making adjustments for future trends.

For purposes of this thesis, four linear regressions were made, using the STAT PACK computer program for the periods 1950-75, 1960-75, 1965-75, and 1970-75 as shown in Table 6-1.

According to the Prices/Year of Table 6-1, the minimum and maximum prices for years 1980, 1990, and 2000 would be:

Year	Min Price	Max Price
1980	£760/mt. ($.60/lb)	£880/mt. ($.70/lb)
1990	£980/mt. ($.78/lb)	£1300/mt. ($1.03/lb)
2000	£1200/mt. ($.95/lb)	£1710/mt. ($1.36/lb)

Note: £1.00 <> $1.75 and 1 mt. <> 2204.6 lbs.

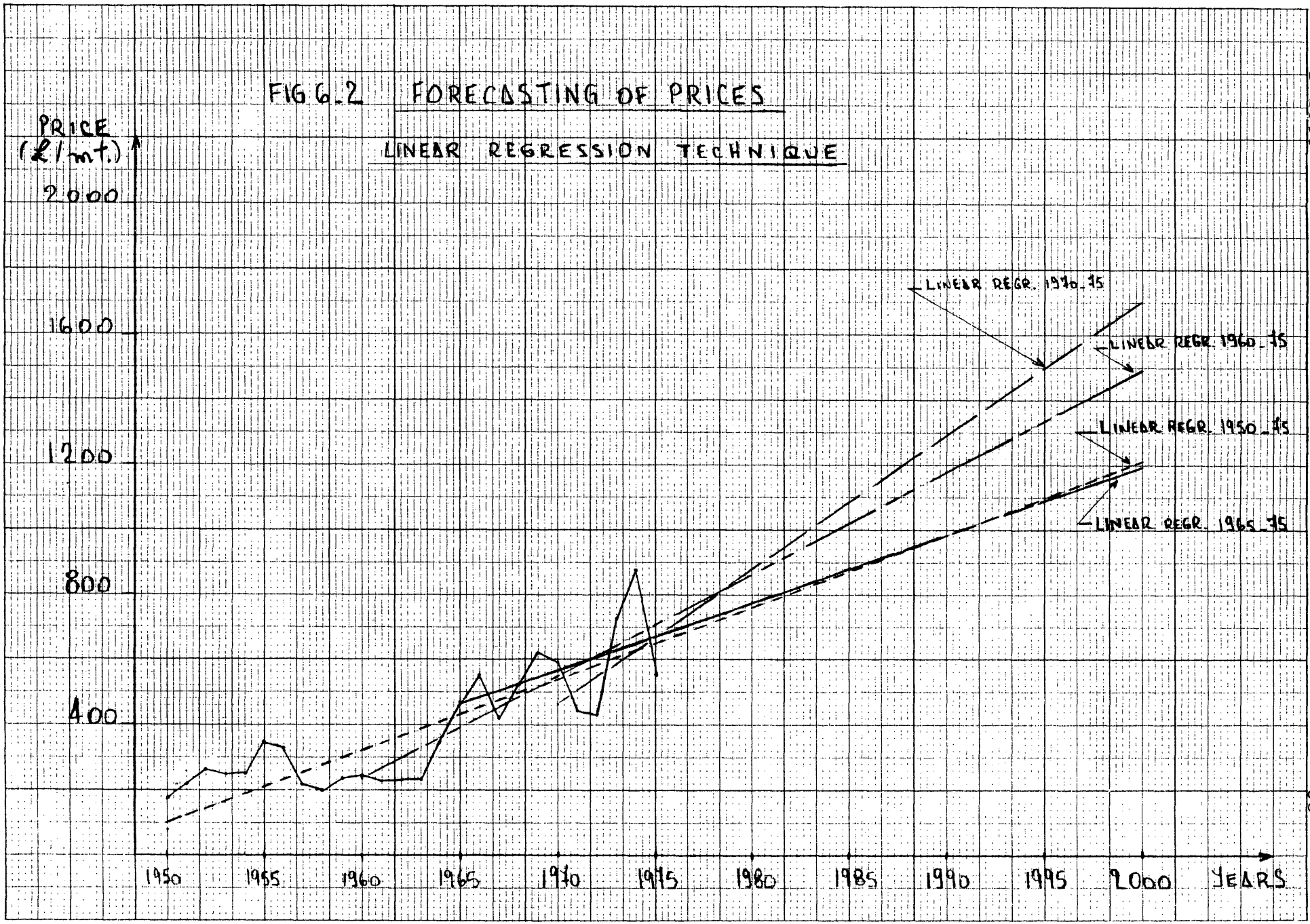
Table 6-1

Forecast of Copper Prices
(Linear Regression Technique)

Years	Linear Regression Equation	Standard Error of the Estimates	Prices/Year (₤/mt) 1980	1990	2000
1950-75	Price=-42,711.5+21.954(year)	112.47	760	980	1,220
1960-75	Price=-62.665.9+32.084(year)	112.03	860	1,180	1,550
1965-75	Price=-40,353.6+20.771(year)	127.50	780	980	1,200
1970-75	Price=-81,000.4+41.375(year)	172.73	880	1,300	1,710

FIG 6.2 FORECASTING OF PRICES

LINEAR REGRESSION TECHNIQUE



6.2.4 Future Values of Prices According to an Annual Average Growth:

According to Ronald Prain in his book "Copper, The Anatomy of an Industry" (1975) more recent studies have brought to light a well-defined trend in prices, based on general cost increases and inflationary pressure. These studies show that over the past forty years, despite market volatility, the copper price has increased fairly steadily, averaging out at about 6 percent annually.

The weakness of this approach is in the selection of the time period to fit the regression equation. The time period selected causes great differences in the projected prices and in effect, states that the conditions of the years chosen will be repeated in the future. In addition, the base year for projection has a profound effect on the result. As examples, the linear regression calculated for the period 1950-75 in Section 6.2.3., and base years 1950 and 1975 can be taken:

Linear Regression 1950-75: a) Base year (1950)=£98.80/mt.
b) Base year (1975)=£647.65/mt.

The future value of these two base years in year 2000 at 6 percent copper price increase per year would be:

a) F.V. of £98.80/mt. = £1820/mt.($1.44/lb)

b) F.V. of £647.65/mt. = £2780/mt.($2.21/lb)

As a real example, the case of Lakeshore venture can be cited in which an increase in price was assumed of 4 percent per year taking as a base year 1969. In that year copper price was £620.75/mt. and 4 percent could be pointed out as a conservative figure. However, this year Lakeshore was shut down due to its losses. Today the price of copper is £756/mt.($.60/lb) in the market and the estimates of Lakeshore called for £850/mt.($.67/lb). This differs altogether from other problems causing production to cease.

6.2.5. Price Determination Formula Developed

The author of this thesis has developed a formula to forecast future prices of copper. The following formula is used:

$$P = \left[\frac{\text{F.V. of Demand (Ref. Cu)}}{10}\right]\left[1 + \frac{p/d}{100}\right]$$

where:

P = Future price of refined copper

F.V. of Demand (Ref. Cu.) = function (GD, AD, T)

GD = average growth demand for the future

AD = average actual demand

T = time in years

p/d = relationship between price and demand for refined copper for the period 1950 to 2000.

Assumptions

- The period 1950-1975 has been chosen instead of any other period because the market conditions after WW II are completely different than before (substitution, recycling, ownership, etc.), differences that can be clearly noticed in the price trends after and before the war (see Fig. 6-1 in section 6.1).
- The forecasting of future prices will take as a base year 1975 and prices will be determined for the years 1980, 1990, and 2000.
- Supply is not taken into consideration because it is assumed that supply and demand would be in equilibrium for the period 1976-2000. Then the F.V. of demand is really the equilibrium point between supply and demand in the future.
- Copper scrap, as was concluded in Chapter 4, Section 2, does not affect prices, and it is assumed to remain at 40 percent of the total consumption of copper per year up to year 2000.
- Substitution of other metals for copper, as was concluded in Chapter 3, Section 5, would not be a factor to influence prices in a way that it has been for the period 1950-1975.
- Grade, capacity, stocks, and cost of production are implicit in the relationship p/d for the period 1950-1975.

- Political and economical affairs are considered to vary the price of copper. In a similar fashion they affected the copper price between 1950-1975, the period in which the Korean and Vietnamese Wars occured, the Zambia-Rhodesia Confrontation (1967), the Recession of 1970, the energy crisis of 1973. Then it is assumed that from 1976 to 2000, there will not be such a political or economical problem to face that the industry has not already faced in 1950-1975 period.
- CIPEC organization could have a greater importance in the market during this period (1976-2000) but only to stabilize prices as was concluded in Chapter 2, Section 7.
-Further processing for copper producer countries would not be of significant importance in the world market as concluded in Chapter 5, Section 3.
- Demand for year 1975 is assumed to be 6,500,000 mt. instead of the real 5,488,800 mt. of refined copper consumed, because the linear regressions made, for the periods 1950-1975, 1960-1975, 1965-1975 and 1970-1975 (with the computer) showed as a most likely value 6,500,000 mt.
- Growth demand for the period 1950-1975 was 4.15 percent. It is considered high for the last quarter

of the century mainly because the industrialized countries with incomes per capita greater than $2,500 per year tend to stabilize consumption per capita instead of increasing this. Then the consumption increase will be due to population growth, especially in developing countries. Since they consume a lot less than developing countries, the most likely growth demand has been lowered to 3.5 percent.

- The p/d relationship would have a most likely value of 9 percent between 1976 and 2000, taking into consideration the relation between these two variables during the period 1950-1975 (see Table 6-2).

A probabilistic analysis was used to forecast the copper prices with the developed formula.

The ranges used for each variable were as follows:

	Values		
Variable	Minimum	Most Likely	Maximum
Growth Demand (GD)	2%	3.5%	5.0%
Average actual demand (AD)	5,000,000 mt.	6,500,000 mt.	7,500,000 mt.
% p/d	5%	9%	15%

The following formulas have been used to draw the cumulative probability graphs (see Fig. 6-3).

Table 6-2

Relationship Between Prices and Consumption 1950-75
(in thousand of mt. and £/mt.)

Year	Consumption Refined Copper	LME Price Refined Copper	% Price/ Consumpt.
1950	2,613.5	178.80	6.84
1951	2,751.0	220.36	8.01
1952	2,806.1	259.35	9.24
1953	2,657.6	251.15	9.45
1954	2,864.3	248.59	8.68
1955	3,249.9	351.42	10.81
1956	3,318.6	328.92	9.91
1957	3,324.7	219.49	6.60
1958	3,347.6	197.38	5.90
1959	3,541.2	237.76	6.71
1960	3,828.4	245.96	6.42
1961	4,096.8	229.57	5.60
1962	4,105.0	233.98	5.70
1963	4,365.3	234.27	5.37
1964	4,855.0	351.07	7.23
1965	4,985.6	468.07	9.39
1966	5,215.5	555.00	10.64
1967	4,894.7	418.04	8.54
1968	5,179.6	525.30	10.14
1969	5,745.6	620.75	10.80
1970	5,835.4	589.45	10.10
1971	5,733.2	444.36	7.75
1972	6,265.1	427.82	6.83
1973	6,947.7	727.10	10.47
1974	6,486.2	877.63	13.50
1975	5,488.8	556.55	10.14

Case I: where the value is $< X_m$

$$P_X = \left[\frac{X-X_1}{X_m-X_1}\right]^2 \left[\frac{X_m-X_1}{X_2-X_1}\right]$$

Case II: where the value is $> X_m$

$$P_X = 1 - \left[\frac{X_2-X}{X_2-X_1}\right]^2 \left[\frac{X_2-X_1}{X_2-X_m}\right]$$

where: X_2 = maximum value X_m = most likely value

X_1 = minimum value P_X = probability of X occurring on a given trial.

One hundred trials were made in order to get a reliable value for each variable.

Using the stack pack computer program, the following results were obtained for the one hundred trials.

Table 6.3

Future Value of Demand of Refined Copper
(thousand mt.)

Year	Mean	Std. Deviation	Max. Demand	Min. Demand
1980	7,499.66	629.73	8,754	5,853
1990	10,600,63	1,165.11	12,883	7,947
2000	14,991.74	2,214.44	19,836	9,976

For a 99.9 percent level of confidence, the most likely value, that is the mean, would vary as follows:

FIG 6.3 CUMULATIVE PROBABILITY GRAPHS

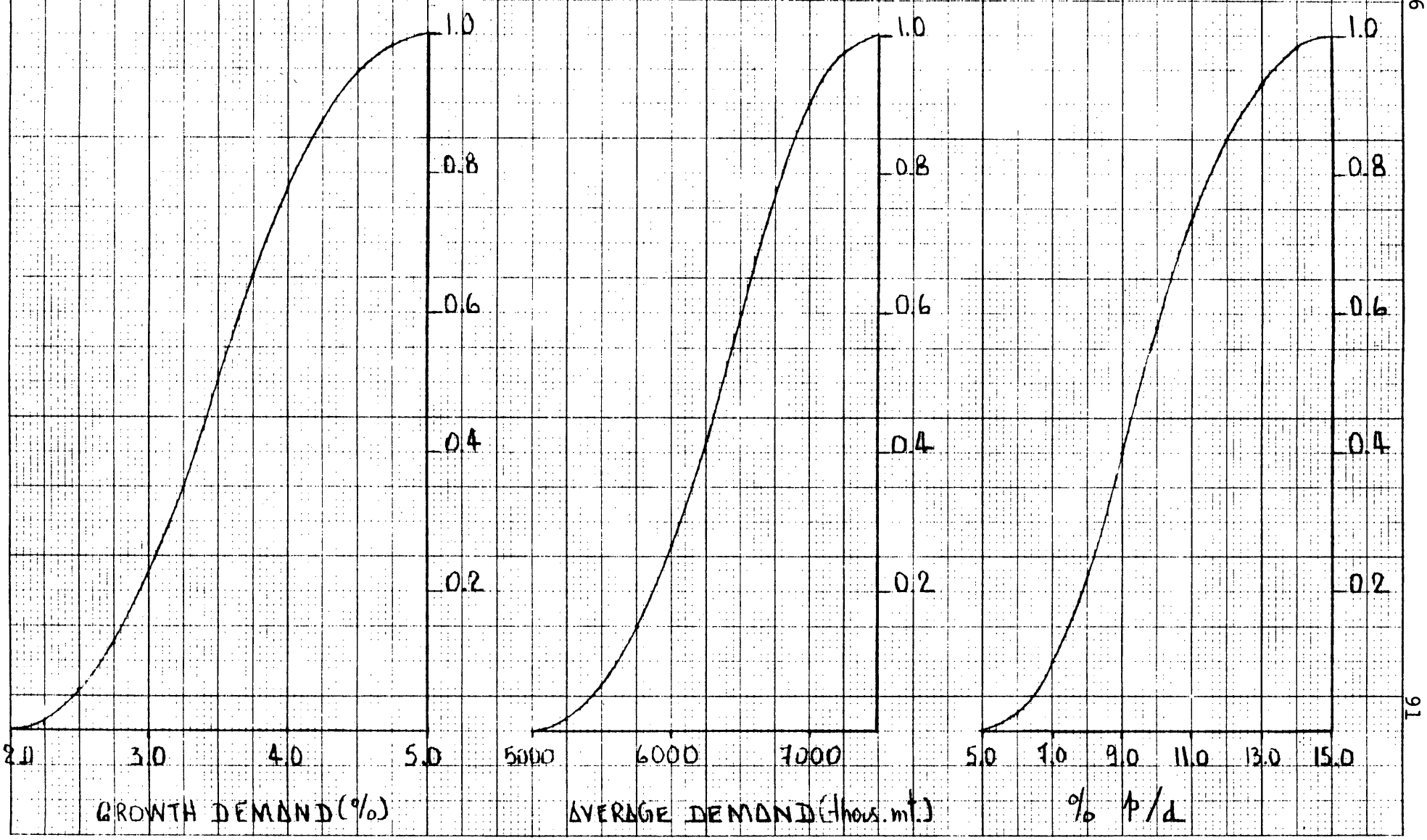


Table 6-4

Most Likely Value of Future Demand with a 99.9% Level of Confidence

Year	Minimum Demand	Maximum Demand
1980	7,293.44	7,705.58
1990	10,219.64	10,981.62
2000	14,267.62	15,715.86

Table 6-5

Future Price of Refined Copper (₤/mt.)

Year	Mean	Std. Deviation	Min. Price	Max. Price
1980	822.29	71.93	650.00	958.00
1990	1,162.30	129.74	865.00	1,428.00
2000	1,645.00	244.73	1,085.00	2,218.00

For a 99.9 percent level of confidence, the most likely value, that is the mean, would vary as follows:

Table 6-6

Most Likely Value of Future Prices with a 99.9% Level of Confidence (₤/mt.)

Year	Minimum Price	Maximum Price
1980	798.77	845.81
1990	1,119.88	1,204.72
200	1,564.97	1,725.03

Table 6-7 shows the prices of refined copper as well as the total demand for copper for years 1980, 1990, and 2000.

Table 6-7

Future Prices and Total Demand of Copper

Year	Future Prices (£/mt.) Minimum Price	Most Likely Price (99.9 level of confidence)	Maximum Price	Future Total Demand (thousands mt.) Min. Total Demand	Most Likely Demand (99.9% Level of Confidence)	Max. Total Demand
1980	650 (.52)	799 - 846 (.63 - .67)	958 (.76)	8,361	10,420 - 11,008	12,506
1990	865 (.69)	1,120 - 1,205 (.89 - .96)	142.8 (1.13)	11,353	14,599 - 15,688	18,404
2000	1,085 (.86)	1,565 - 1,725 (1.24 - 1.37)	2,218 (1.76)	14,251	20,382 - 22,451	28,337

Note: Quantities shown in parentheses are in dollars per pound.

Total demand for copper is equal to total demand for refined copper times 100/70.

6.3 Summary

At the beginning of this chapter, the statement was made that it is very difficult, if not impossible, to forecast commodity price. However, any time a new project is developed, price forecasts are made for the evaluation of profitability.

The model developed in this thesis makes the procedure of price forecasting less complicated. The model appears valid under present assumptions. Unforseeable situations would reduce or eliminate the model as a projected tool. In any circumstance, the experience and judgement of the analysts play a major role in forecasting.

CONCLUSIONS

This thesis has discussed the international marketing of copper. Special emphasis was given to the analysis of copper price fluctuations. Factors whose influence in the copper market were thought of major importance were studied. The analysis led to recommended actions and conclusions regarding the copper market.

Main factors taken into consideration were:

- Commodity exchange systems
- CIPEC influence on price
- Substitution effects on copper market
- Copper scrap considerations
- Further processing of copper in developing countries
- Political and economical considerations

Price fluctuations have been very sharp during the 1950-75 period. There is little real control by the commodity exchanges toward establishing a realistic price for copper. Their function has become one of reflecting in price terms the marginal balance of supply and demand. Because they deal in a relatively small sample of the copper trade

of the world, it is inevitable that price fluctuations on the exchanges are wider than those were if they would trade the bulk of the copper world production.

The exchange pricing system has been largely questioned by developed and developing countries. The producers answer was the creation of CIPEC. However, up to the present, this organization does not have any control over prices. In the future, its importance (as new members with considerable export production are included) will be of greater significance, while exchanges, especially LME, will lose importance as determinants of price in the world.

Substitution played a role during the period 1950-75, but its intensity has decreased in the early 1970s. It is expected to maintain its share gained in the copper industry but not increase it, mostly because the price gap between copper and aluminum is narrowing, and besides the increased cost of energy is of great importance from now until the end of this century.

Copper scrap did not influence the price of new copper during the period 1950-75. Even in 1973 and 1974 when the copper price reached its highest value in its whole history, scrap maintained its usual share of the market, that is, 40 percent of the total copper consumption. Since for the near future and up to the year 2000, it is not foreseen

such a situation that could be worse than before, scrap is assumed not to be a factor to influence the market of virgin metal.

Further processing of copper in developing countries is possible in the future but only in limited quantities. Their significance would not be important enough to change the actual conditions of the market.

Political and economical considerations will be as troublesome as before. They will affect the market only in the short-run and with less significance since new important producers through the world would be in the market. Briefly resuming the actual market conditions would be maintained in the last quarter of the century as today with significant improvements in price stabilization due to actions taken by CIPEC, or agreements between producers and consumers, or due to positive actions implemented by the Organization for Economic Cooperation and Development, such as the Commodity International Monetary Fund.

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