OPEC AS A MODEL FOR COPPER EXPORTERS: POTENTIAL GAINS AND CARTEL BEHAVIOR

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INTRODUCTION

THE unprecedented success of OPEC[1] in raising the price of oil by over 700 per cent within a six-year period (1970–76) and multiplying the oil revenues of its members by a factor of at least ten[2] raised the question whether other primary commodity exporters will emulate OPEC's model with a similar success. Among the mineral commodities, bauxite, tin, and copper appear to satisfy the main prerequisites for a successful OPEC-type strategy.[3] The present study investigates whether there are any substantial gains to be earned from the cartelization of copper and whether in the presence of such gains individual interests are compatible with group welfare to the point of giving rise to a stable and enduring cartel.

The Intergovernment Council of Copper Exporting Countries, CIPEC in French abbreviation, was established in 1967 by four major copper exporting countries, Chile, Zambia, Zaire, and Peru with headquarters in Paris. The objectives of CIPEC are, in general, to promote the contribution of copper resources to economic development of its members and in particular to "coordinate measures designed to foster real earnings from copper exports...[and] assure greater price stability in the international copper market" [5, p. 255]. However, apart from any superficial similarities of CIPEC with OPEC it is not clear that there are any significant gains to be earned from the cartelization of copper.

OPEC's success may be attributed to three main factors: (1) its overwhelming-

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1 OPEC is the abbreviated name for the oil cartel "Organization of Petroleum Exporting Countries."

2 Based on figures reported in Ellis [6].

3 See, for example, Barker and Page: "In spite of these constraints we would conclude that mineral exporters are potentially capable of solving the difficulties and following a price increasing strategy..., the mineral exporters at least start with the advantage of OPEC's precedence in the solution of many problems" [4, p. 90].

ly high share in world oil supply (75 per cent of world oil trade and 76 per cent of world oil reserves[4]); (2) the absence of close substitutes and consequently the inelastic demand for oil (0.04 in the short run and 0.33 in the long run at a price of $6 per barrel and 0.09 and 0.90 respectively at $12 per barrel [12, p. 8]); and (3) the inelastic non-OPEC supply (0.9 and 0.35 at $6 and 0.16 and 0.52 at $12 a barrel [12, p. 8]). These magnitudes imply a price elasticity of demand for OPEC oil,[5] at $6 a barrel, significantly less than one in both the short and the long run. Even at $12 a barrel the short-run elasticity is still substantially less than one. Under these conditions OPEC's spectacular success is not surprising.

CIPEC, however, commands a much lower share in world copper supply (less than 60 per cent of world trade and only 48 per cent of world copper reserves[6]). Moreover, the existence of close substitutes to copper such as aluminum and plastics and the importance of production from scrap are likely to affect the elasticity of both world demand for and non-CIPEC supply of copper and consequently the magnitude of potential gains from cartelization. On the other hand, these gains may be enhanced by a possible enlargement of CIPEC to include other copper exporters such as the Philippines, Indonesia, Botswana, Uganda, Mauritania, and Papua New Guinea.

Canada, the largest non-CIPEC net exporter of copper, is not likely to join CIPEC for a number of reasons: (1) unlike present or prospective members of CIPEC, Canada has a high share in the production and trade of secondary copper (from old and new scrap); (2) Canada is, itself, a significant consumer of copper, indeed the world's highest per capita consumer,[7] with a highly developed industrialized economy not particularly dependent on copper exports; and (3) Canada is becoming increasingly a major world copper producer steadily increasing its share of the world copper market at the expense of CIPEC members. Under these conditions Canada is likely to provide the most effective constraint from the supply side to any attempt by CIPEC to raise prices by curtailing output. Relatively small price increases may lead to a cumulative shift of Canadian potential, yet underdeveloped, deposits into the economic range, thus, easing any short-run pressure on prices from CIPEC's action.[8]

Clearly, CIPEC cannot afford to ignore the Canadian copper industry in contemplating concerted action to increase revenues or stabilize prices. Indeed,

[4] Based on figures reported in Ellis [6, pp. 23–25]. Reserves refer to 1973 and exports to 1972. "World" excludes the Centrally Planned Economies throughout the present study.

[5] See Appendix for the formula relating the price elasticity of demand for cartel output to the price elasticity of world demand for the product, to the price elasticity of non-cartel supply and to the market share of the cartel.

[6] See Table I (Reserves refer to 1970 and trade to 1969).

[7] Kay and Mirlees [9, p. 154] report that Canada's per capita consumption of copper is 148 compared to 100 for Britain, 105 for the United States, 96 for Japan, 87 for France, and 111 for Germany.

[8] Canada's undeveloped low grade deposits are not likely to provide a strong incentive for the country to join CIPEC since cartelization would mean curtailment rather than expansion of output.

observers from Canada were invited to attend the 1971 Conference of CIPEC Ministers in Kinshaza, Zaire. On the other hand, Canadian copper policies cannot ignore the existence and actions of CIPEC if such a cartel is proved successful in controlling copper prices. A successful CIPEC would be setting prices to maximize profits (or revenues) based on conjectures of what Canadian and other competitive supply would be, while Canada, behaving as a price taker, would choose its output to maximize profits given the expected price reaction of CIPEC.

Whether OPEC-type strategies by CIPEC would be proved successful depends not only on the existence of potential gains from cartelization for the group as a whole but also on the degree of compatibility of individual members' interests which would determine the endurance and stability of the cartel. While OPEC is not the "ideally" homogeneous group, as recent experience has shown, it has, nevertheless, a more or less homogeneous core group, the Arab States, which can maintain a reasonable stability in cartel behavior.[9] More importantly, the gains from oil cartelization have been proven to be large enough to compensate for any disparity of interests among members resulting in eventual consensus and adherence to agreed upon behavior.[10] In CIPEC not only the core group is missing but differences among members in copper reserves and current needs for funds (let alone political and social disparities) loom too large in comparison to potential gains to produce even a delicate balance in which the welfare of the group as a whole overrides the interests of individual members.

Accordingly, the remainder of this study is organized into three sections. In the following section we investigate whether there are any substantial gains from the cartelization of copper by calculating the price elasticity of demand for CIPEC copper. In Section II we examine the likelihood of cartel behavior by CIPEC members in the light of their differences in copper reserves and current needs for funds. The study ends with summary and conclusions.

I. POTENTIAL GAINS FROM CARTELIZATION

A measure of the potential benefits to CIPEC from OPEC-type strategies may be obtained by calculating the price elasticity of demand for CIPEC copper, ε_{DC}, defined as the ratio of the proportionate rate of change in the quantity of copper demanded to the proportionate rate of change of its price.[11] The absolute value

[9] In a number of recent articles OPEC is portrayed as a two-part cartel "composed of a block of spender countries with large cash needs and a block of saver countries with little immediate need for cash and a lower discount" [8, p. 139]. A similar idea was advanced by Penrose [11].

[10] Witness the initial confrontation and eventual compromise among OPEC members whenever the issue of increasing the price of oil comes up. For instance in the most recent OPEC meeting (Abu Dabi, December 1978) Iraq was arguing for a 25 per cent increase, Kuwait for 15 per cent, and Venezuela for 10 per cent while Saudi Arabia favored a continued freeze. The meeting ended with an agreement of a total increase of 14.5 per cent by October 1, 1979 implemented in quarterly installments [1, Dec. 16 and 18, 1978].

[11] Following Takeuchi [15, pp. 1–29] we assume that there is only one price in the world copper market ignoring the once considerable divergence between U.S. producer's price and London Metal Exchange (LME) price.

of this elasticity, $|\varepsilon_{DC}|$, must be less than one for a cutback in supply to lead to an increase in CIPEC's export revenues.[12] If $|\varepsilon_{DC}|=1$ export revenues would remain unaffected while if $|\varepsilon_{DC}|>1$ export earnings would decrease by any attempt to cut back supply to raise prices. In fact, in the latter case CIPEC should increase output and accept lower prices if its objective is to maximize revenues. While in the case $|\varepsilon_{DC}|<1$ there is room for OPEC-type strategies, the degree of potential success is inversely related to the absolute size of this elasticity. The latter is itself inversely related to CIPEC's share in world copper supply, α_C, and positively related to the price elasticity of non-CIPEC supply, ε_{SN}, and to the price elasticity of world demand for copper, ε_{DW} (see Appendix for the precise formula and its derivation).

Part of OPEC's success has been attributed to the inelastic demand for oil in the absence of close substitutes.[13] Unlike oil, copper faces keen competition from aluminum and plastics and is expected to be much more price elastic than oil. Short-run and long-run[14] demand elasticity for the major copper consumers, Japan, the United States, and Western Europe, and for "the rest of the world"[15] were estimated by Banks [2][16] and Fisher, Cootner, and Baily [7][17] (henceforth FCB) (see Appendix Table I). On the basis of the Banks's estimates Takeuchi

[12] The copper cartel may have a number of alternative or supplementary objectives such as profit maximization, price stabilization, or minimization of substitution against copper. Similarly there may be a number of alternative or complementary policy instruments such as cost-pricing, buffer stocks, support buying at LME, or even creating an International Metal Exchange. As the objective of this paper is to study OPEC-type strategies as they relate to copper, we concentrate on the objective of maximizing gross export revenues through supply cutbacks or via monopoly pricing as practiced by OPEC. It must be noted, however, that ignoring extraction costs is easier to justify in the case of oil than of copper. For instance, in 1975 the extraction cost of a barrel of Iranian oil was about \$0.053 compared to its market price of \$9.60 while in 1970 the cost of a pound of Chilean copper was around \$0.31 compared with a market price of \$0.50 [14, p. 5].

[13] See, for instance, Pindyck [12] and Ellis [6].

[14] The concepts of "short run" and "long run" are used rather loosely throughout the paper. The short run may be understood as the period over which mine capacity is fixed. The rate of output may be altered by varying the rate of utilization of existing productive capacity, or by changing the level of stocks. The long run is a longer period during which production may be further altered by expanding or contracting mine capacity. In most elasticity estimates referred to in this study the length of "short run" is a year although it clearly takes more than a year (usually four or five) to open a new mine.

[15] The centrally planned economies (CPEs) are excluded throughout the study. "The rest of the world" (or "rest" for short) when in reference to copper demand includes all countries except Western Europe, Japan, North America, and the CPEs, and when in reference to supply it includes all major copper producing countries except CIPEC, North America, and the CPEs.

[16] Banks used quarterly data for the period 1955–67 and simple least squares regression to estimate linear and log-lined equations involving lags. Hence, the length of the short run depended on the lag-structure. He provided individual estimates for the major European countries but no estimates for the rest of the world as defined above.

[17] FCB [7] using 1950–68 data and linear regression equations estimated own price elasticities, cross-price elasticities (price of aluminum) and income elasticities. In one set of equations for the United States and Japan the index of construction and in another the index of industrial production are used to represent the level of economic activity in each country.

[15] inferred that the short-run elasticity of demand for copper in the world market is in the range of -0.1 to -0.3. On the basis of the FCB [7] estimates, evaluated at the point of the means, we calculated short- and long-run world elasticities by weighing each country's (or region's) elasticities by the respective 1963 and 1970 shares in world copper consumption.[18] No substantial difference between the two years of reference was found although the share of the United States in world copper consumption has been falling, that of Japan and the rest of the world rising, and that of Europe fairly constant. The short-run elasticity of demand was found to lie between -0.13 and -0.15 (within Takeuchi's range) and the long-run ε_{DW} between -0.46 and -0.52.[19] Pindyck [12], using 1974 weights and the FCB regional elasticities, arrived at a world demand elasticities of -0.16 in the short run and 0.80 in the long run at a price of \$0.75 per pound.

Turning to the supply side, we would expect the supply of non-CIPEC copper, unlike that of non-OPEC oil, to be quite elastic since Canada, a major exporter of both primary and secondary copper,[20] is not a CIPEC member at present and is not likely to join in the future. Furthermore, given Canada's enormous undeveloped low-grade deposits, an even greater effect is to be expected in the long run.[21] Unfortunately, there is very little information on the price elasticity of copper supply from Canada and from other non-CIPEC suppliers. Banks [2] obtained estimates of short- and long-run supply elasticities both inclusive and exclusive of scrap for CIPEC, Canada, and the United States,[22] while FCB ob-

18 The 1963 and 1970 weights used were the following respectively: the United States=0.38, 0.32; Japan=0.10, 0.15; Europe=0.43, 0.42; Rest=0.09, 0.11. These were calculated on the basis on consumption data reported by Takeuchi [15, p. 5].

19 Takeuchi [15] made no inference about the long-run demand elasticity except to state that it must be substantially higher than the short-run estimate of 0.2.

20 Secondary copper is believed to account for about 40 per cent of world's copper supply in which CIPEC's share is negligible [15, p. 7]. Canadian mine production is of the same order of magnitude as that of Chile. The 1975 figures were 713 and 793 thousand metric tons respectively (*Mindeco Mining Yearbook of Zambia*). Canada exports more copper (including secondary) than either Peru or Zaire and about the same as Zambia; the approximate figures for 1973 were of the order of 650, 250, 500, and 700 thousand metric tons respectively (*Mindeco Mining Yearbook of Zambia, 1974* and *Canadian Mineral Survey, 1974*).

21 The Canadian known copper reserves presently estimated around 40 million tons of copper content are larger than any CIPEC member except Chile although of a lower average grade (0.4 in 1970). But what is of greater importance is the availability of enormous possible or probable deposits of lower grade which are gradually entering the profitable range. The estimated Canadian copper reserves were only 8 million in 1965, 10 million in 1969, 30 million in 1971, and 35 million in 1975. The reserves figures were obtained from the Commodity Data Summary Sheets, Division of Nonferrous Metals, Bureau of Mines 1964, 1972, 1976, and 1977. The average grade figures were obtained from De Vletter [5, p. 253]. The reserves and grade figures for CIPEC members are found in Table I.

22 Banks [2] employed least square techniques and annual 1950–67 data to estimate simple linear equations with or without lags (a strong time trend was observed). Takeuchi [15] reports fairly similar estimates for the World, the United States, Canada, and Chile by J. P. Newhouse and F. A. Sloan, "An Econometric Study of Copper Supply," (January 1966).

tained estimates for primary and secondary copper separately for all these producers as well as for the rest of the world. From these estimates it appears that supply elasticities are in general lower for CIPEC members than for non-members;[23] among the latter, however, Canada has the lowest elasticity in the short run and the highest in the long run indicating an extremely slow speed of adjustment (see Appendix Table II). This may not be surprising when considering that Canada's copper deposits are marginal at present costs and supply increases in response to higher prices often necessitate opening of new lower grade mines. As FCB [7] put it "the very high long-run elasticities ought to be expected where new mines are developing and old ones are far from exhausted."

On the basis of the Banks's estimates, Takeuchi [15] inferred that the short-run elasticity of non-CIPEC supply, ε_{SN}, is somewhere between 0.16 and 0.3 when only mine production is considered and between 0.2 and 0.4 when production from scrap is included, while the long-run ε_{SN} is considerably larger, close to 1.0 or higher. On the basis of the FCB estimates and using as weights the 1963 and 1970 shares[24] of the United States, Canada, and "the rest of the world" in non-CIPEC mine production, we found short-run ε_{SN} to be 0.64. When the fairly self-sufficient U.S. market was included, the value of ε_{SN} rose to 0.76 but fell as low as 0.19 when, in addition, all major exporters besides Canada were assumed to have joined CIPEC. The upper bound of our range is higher than Takeuchi's reflecting the high short-run elasticity of "the rest of the world" ignored by Banks [2] and Takeuchi [15]. If secondary copper is included the range may be raised to 0.2–0.8. The long-run supply elasticities were, in all cases, considerably higher than one (even higher than 3.0), although it is not clear how seriously their cardinal magnitude should be taken.[25]

A word of caution is in order. The above estimates may at best be regarded as tentative because of two important limitations. First, they ignore the fact that, in a world of heterogeneous deposits with differing costs of development and extraction, the size of supply elasticity would certainly depend on the cost range under consideration.[26] Second, the above estimates ignore the fact that the long-run copper supply will be determined by existing mines as well as new ones. A more appropriate concept would have been the "price elasticity of recoverable reserves," but this would require extensive research beyond the limited scope of this study.[27]

[23] FCB [7] included the two smaller (in terms of output) CIPEC members, Peru and Zaire, in "the rest of the world" but this does not affect our conclusion as both these producers have very low supply elasticities.

[24] The respective weights for the United States, Canada, and the rest of the world were 0.41, 0.15, and 0.44 in 1963 and 0.41, 0.16, and 0.43 in 1970. Since the change is negligible we report only the results obtained with 1970 weights.

[25] For instance, Banks's estimate of supply elasticity of 42.24 for Canada is rather absurd although virtually all the studies we know of report an elasticity higher than ten!

[26] Takeuchi [15] provided some calculations of the price elasticity of world supply within various cost ranges between $0.20 and $0.50 per pound. His estimates lie between 0.7 and 2.00 but refer to the world as a whole rather than to non-CIPEC producers alone.

[27] Takeuchi [15] also made an attempt to calculate such an elasticity using figures of recoverable reserves at different prices supplied by the U.S. Department of the Interior.

As indicated in the beginning of this section, CIPEC's market power, that is CIPEC's ability to reap benefits by manipulating copper markets, depends on the magnitude of the elasticity of demand for its copper, ε_{DC}. Only if the latter is less than one (in absolute value) would any benefits accrue to CIPEC by acting as a group. We have already found the elasticity of non-CIPEC supply to be in the range 0.19–0.80 in the short run and substantially greater than one in the long run[28] and the elasticity of world demand around 0.14 and 0.50 respectively. To calculate ε_{DC}, using the formula of Appendix, we further need CIPEC's share in world copper supply. OPEC's overwhelmingly high share in world oil supply (64 per cent of world production, 75 per cent of world exports, and 76 per cent in world oil reserves)[29] is largely responsible for its success story.

In the short run, the relevant concept is a cartel's share in total world production or world exports. Considering CIPEC's share in world production, including scrap (33 per cent),[30] and using the formula of Appendix we find that, with $\varepsilon_{DW} = -0.14$, the prospects for CIPEC increasing its earning through supply cutbacks are good ($|\varepsilon_{DC}|<1$) as long as the elasticity of non-CIPEC supply is quite low, less than 0.28. As we found that the latter may be as high as 0.80, this is hardly an optimistic result for CIPEC. If, however, CIPEC was to open its door to the rest of the major copper exporting developing countries, its share would rise to 40 per cent and the elasticity of non-CIPEC supply would fall enough to create the potential for short-run benefits, as ε_{DC} is at most -0.80 and possibly -0.60, if we exclude the fairly self-sufficient U.S. market.

It could be argued, however, that given the considerable lags between production and sales, the appropriate concept in the short run is CIPEC's share in the trade flow or the total world exports (60 per cent). Then CIPEC's prospects for short-run gains through production cutbacks are fairly good ($\varepsilon_{DC} = -0.63$), even under existing membership and excellent ($\varepsilon_{DC} = -0.33$), under an enlarged participation, due to the very slow speed of adjustments of the remaining competitive fringe, consisting mainly of Canada if the United States is excluded.[31]

In the long run the elasticities of world demand and non-CIPEC supply are larger than in the short run and, as a result, the long-run ε_{DC} will be larger, in

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He obtained an estimate of 0.7, which supports our findings of a fairly high elasticity of copper supply.

28 Note that in a recent study Pindyck [12] using also the FCB [7] estimates obtained similar results (0.20 in the short run and 1.6 in the long run).

29 Based on figures reported in Ellis [6].

30 This and all subsequent figures on CIPEC's share are based on data found in Takeuchi [15], Banks [3, p. 51], and Seidman [14, p. 51].

31 There is a limitation to the above calculations as not all trade flows represent actual exports but a great part refers to movement of copper among net importers. Takeuchi [15] pointed out that the appropriate concepts are the elasticities of import demand by the net exporting region and of export supply from the net exporting region outside CIPEC. Following Takeuchi [15] we calculated such elasticities and using CIPEC's share in the total exports from "net exporters" we recalculated the elasticity of demand for CIPEC copper, but our previous results did not change significantly: the short-run gains from cartelization are at best moderate under existing membership but potentially high under enlarged participation.

absolute value, and the prospects of success, dimmer. Three alternative meanings may be attached to the long-run share of CIPEC, giving rise to similar results. First, considering CIPEC's share in world mine production (40 per cent), and a long-run ε_{DW} of -0.50, a simple calculation reveals that CIPEC cannot increase its export earnings even if non-CIPEC supply was perfectly inelastic ($\varepsilon_{DC} = -1.25$). If, instead, CIPEC's share in projected world mine capacity (38 per cent) is considered things worsen further; even under enlarged membership ε_{SN} must be lower than 0.1. Our estimate of $\varepsilon_{SN}>1$ leaves absolutely no room for monopolistic manipulations on CIPEC's part ($\varepsilon_{DC} \leq -1.77$).

Finally, considering CIPEC's share in world recoverable reserves we obtain a similar result: at a price of 80¢ per pound CIPEC's share is only large enough (50 per cent) to keep its demand elasticity down to unity under an infinitely inelastic supply from the competitive fringe. As the latter appears to be highly elastic, only damage could be done by attempting to raise prices or restrict output. Under enlarged membership and at a higher price—we found no reliable estimates —CIPEC's recoverable reserves may increase considerably but this may well be offset by a substantial shift of low grade, as yet undeveloped, Canadian deposits into the economic range. Indeed, Canada has been increasing its production and export shares, slowly but steadily, at the expense of CIPEC's members such as Zambia and Zaire (see Appendix Table III).

Having obtained results that reaffirmed those of previous studies [12] [15], we may conclude that the demand for CIPEC copper is moderately inelastic in the short run but quite elastic over the long run. In the light of the consequently moderate gains to be had from the cartelization of copper, we proceed to examine the likelihood of cartel behavior by CIPEC members in the face of their conflicting individual interests.

II. LIKELIHOOD OF CARTEL BEHAVIOR

The analysis of the preceding section has shown that, even after allowing for the limitations of the approach, CIPEC will at best be able to reap a short-run gain if it were to follow monopoly pricing. Opening its doors to other copper exporting developing countries would increase this short-run gain but no foreseeable enlargement would enable CIPEC to reap any long-run benefits from cartelization. Moreover, any short-run gains should be balanced against long-run losses and the not negligible costs of effective cartelization.

Long-run losses include both losses of market share to non-CIPEC producers and losses of consumers to copper substitutes such as aluminum and plastics. In addition, there exist significant costs in creating and holding together a cartel: both political and financial costs of coordination, of policing output and price agreements, of carrying stocks and of undertaking the risk of being undercut by each other. Finally, as Pindyck [12, p. 24], who obtained similar results, pointed out, "the increased [short-run] profits require fluctuations in price. . . that cartel members would probably wish to avoid, and the consumers could anticipate and counteract through stockpiling" [12, p. 24]. Moreover, price instability in the

pursuit of short-run gains may lead, in the long run, to a cumulative and partly irreversible switch to the highly stable aluminum market.

Whether CIPEC, as a group, will attempt to reap these potential short-run gains through concerted action depends on the relative size of these gains compared to the long-run losses to other producers and copper substitutes and on the rate of discount at which the latter are evaluated. It is clearly a question of revenues *now* versus revenues *later*. But, even if we were to assume an enlarged CIPEC membership[32] and a high enough discount rate on part of CIPEC as a group to make cartelization and monopoly pricing appear attractive, still there remains the question of compatibility of individual members' interests to group welfare. Will the members agree on and adhere to a policy which appears profitable to the group as a whole but not equally advantageous to each member? This will largely determine whether CIPEC is likely to succeed as a coherent, stable, and enduring cartel behaving as a monopolist rather than as an unstable oligopoly.

While all current CIPEC full members[33] are developing countries and major copper exporters with negligible domestic consumption, they have significant differences in current needs for funds, size of copper reserves, and cost of production. Differences in current needs for funds may be due to differing levels of development and absorptive capacity, differing population pressures or development ambitions or plainly differing discount rates. Differences in production costs may be due either to varying degrees of resource accessibility and quality of ore or to transportation problems arising from inadequate infrastructure or political conflicts. Finally, regarding reserves availability what is of importance is not the absolute size of the reserve base but the reserves/production ratio of each producer or the expected average life of known reserves at the current or projected rate of production.

Countries with a large reserve base and low production costs are likely to be interested more in the long-run situation and want to avoid too high copper prices which will encourage substitution for aluminum in the longer run. Their large reserve base implies an almost negligible effect of current production on future revenues; a ton of copper not produced today has very small present value even at a low discount rate. It pays to produce as long as the price exceeds their relatively low average production cost and the revenues so obtained earn a positive return.[34] For these two reasons countries in this category would be willing to offer relatively more output at lower prices than countries with a

[32] Already Indonesia has become a full member of CIPEC while Australia, Mauritania, Papua New Guinea, and Yugoslavia are associated members [1, July 8, 1978].

[33] Here we will discuss the compatibility of interests only among the four founding CIPEC members (Chile, Peru, Zambia, and Zaire) which would continue to be the major exporters under any foreseeable enlargement of CIPEC. The coherence among the "big four" is a necessary though not a sufficient condition for a successful cartel.

[34] Expectation of substantially higher future prices (or lower costs) is not likely to affect significantly their rate of output since their large resource base implies a negligible user cost, that is, effect of current output on future availability.

shorter reserve life and higher production costs. The former will press for high prices only if they have an urgent need for funds, thus, discounting heavily any future losses from a demand shift towards copper substitutes.

On the other hand, countries with a low reserve/production ratio and high production costs[35] would most likely want higher prices and production cutbacks. Higher prices will help them cover, not only their high production cost, but their also high user cost (the cost in terms of use of depletable resources) as well. Moreover, a cutback in output will tend to lower both of these costs. These countries would be more than eager to pursue a policy of higher prices by withholding supplies. Perceiving a short life for their reserves, anyway, they would "care less" about any potential future damage to the copper market as a result of high current prices. Countries in this group would want to avoid output cutbacks (even seek output increases along with higher prices) if they have an urgent enough need for funds today to discount heavily the effect of current output on future availability (user cost). In this group we may also include countries with a sort of "backward-bending" supply curve. These are countries with limited absorptive capacity but, at the same time, heavily dependent on copper (for government revenues, foreign exchange, and development expenditures) so that they desparately need to attain a certain level of annual revenues. This could be attained either by high prices or large output or a combination of the two. Since they fear depletion of their limited copper reserves, they would press for high prices and the higher the prices they succeed in obtaining, the lower the output they would be willing to offer. Conversely, if prices are falling they will want to supply more to attain the needed level of revenues.

The Latin American producers, Chile and Peru, belong to the first group: they have large reserve/production ratios, low production cost (see Table I, rows 12–15) and no immediate need for revenues. Chile, with a relatively small population, has almost one-third of world copper reserves and its GNP per capita is only second to that of Peru among CIPEC members (see Table I, rows 1–4). Peru, with a somewhat higher population (15 million), has probably the world's highest reserve/production ratio, and the lowest production cost, and is not particularly dependent on copper (see Table I, rows 1, 2, and 8–15). Peru has many other sources of revenues and its GNP per capita is the highest among CIPEC members. Clearly, both these producers would favor a high rate of output at moderate prices. Of course, they would not go for the highest possible output at too low a price but they are simply in the position of making a free choice between current and future revenues.[36]

The African producers, Zambia and Zaire, belong clearly to the second group; they have low reserves, both in absolute size and in relation to their current

[35] High production costs are usually associated with a low production/reserve ratio because of diminishing accessibility and quality of ore with cumulative production [10, sections 5.5 and 7.1].

[36] Even if a country does not have an urgent need for funds to invest in the domestic economy or at any rate has limited absorptive capacity there is always the option of investing in the international capital market as some of the Arab oil producers often do.

TABLE I

COMPARATIVE POSITION OF THE ECONOMY AND COPPER INDUSTRY OF CIPEC MEMBERS

	Rows	Zambia	Zaire	Chile	Peru
1	Population (millions), 1975	4,280	24,271	10,585	15,387
2	Population growth rate (per cent p.a.), 1950–75	2.8	3.2	2.2	2.5
3	GNP per capita (U.S.$), 1975	439	139	700	748
4	Growth rate (per cent per year), 1950–75	1.9	1.6	0.7	2.5
5	Multi-year development plan	Yes	No	Yes	Yes
6	Copper production (1,000 metric tons), 1976	760	530	990	270
7	Copper production: world position (%)	11.4	8.0	14.9	4.0
8	Copper share in GNP (%), 1965	34	23	3	1.5
9	Copper share in GDP (%), 1968	46	18	6	7
10	Copper share in exports (%), 1970	93	61	66	19
11	Copper share in gov't revenues (%)	68	45	14	12.5
12	Reserves (copper content in million tons), 1976	31.8	18.2	93.0	32.9
13	Reserves / production ratio, 1976	41.8	53.2	93.9	121.9
14	Expected life of reserves (years)	25	30	55	70
15	Mining costs (cents per pound), 1970	29.0	32.5	24.3	22.4
16	Average grade in situ of ore mined (%), 1970	3.38	4.2	1.53	1.14
17	Projected capacity: low-high, 1980	900–970	700–850	1,000–1,325	400–500
18	Forward linkages: per cent refined, 1966	79	50	40	20
19	Backward linkages: employment (%), 1970	14	4	1.5	2

Sources: Rows 1–4: computed from World Bank, *World Tables, 1976,* and data tapes, World Bank *Atlas,* March 1977; rows 6–7, and 12: Division of Nonferrous Metals, Bureau of Mines, January 1977; rows 8–11: [2, p. 5], and M. Bostock and C. Harvey, eds., *Economic Independence and Zambian Copper: A Case Study of Foreign Investment* (New York: Praeger, 1972); rows 13–14: calculated from rows 6 and 12; row 14 is a rough estimate assuming an exponential growth of consumption of 4.1 per cent p.a.; rows 15–16: [5, pp. 253–54]; row 17: [14, p. 57]; rows 18–19: [14, p. 5].

output rates, high production costs,[37] and pressing or inflexible needs for current revenues. Zaire, with by far the largest population (around 25 million), and the lowest GNP per capita (one-fifth that of Chile) among all CIPEC members has the smallest resource base, very high production costs (see Tabel I, rows 1–4, and 12–15), and a pressing need for immediate funds to raise the subsistence levels of income of a rapidly growing population and to finance the strengthening of its defences against guerilla attacks on the copper-rich Shaba province. Thus,

[37] Although the average grade in situ of ore mines in Zambia and Zaire is more than double that of Chile and Peru (see Table I, Row 15), the two African countries have higher production costs for the following reasons: (1) significantly lower production/reserves ratio; (2) differing geological origin and structure of the ore requiring relatively high extraction and treatment costs; and (3) higher transportation costs due to distance from markets, landlocked location, or political conflicts.

Zaire would seek the highest possible revenues through both high prices and a large volume of output. Its discount rate is too high to be concerned either with the effect of higher output on future revenues or with the effect of higher prices on the future of the copper market. Moreover, Zaire, striving to maintain good relations with the industrialized copper importing countries, is unlikely to withhold copper supplies.

Zambia, with a small population (only 4.28 million) and GNP per capita four times that of Zaire, is not under the same pressures for immediate revenues (see Table I, rows 1–4). Nevertheless, having the world's most dependent economy on a non-renewable resource[38] (see Table I, rows 8–11), Zambia needs to attain a certain level of annual revenues for its survival as well as the implementation of its overly ambitious development plans. On the other hand, Zambia has CIPEC's lowest reserves / production ratio and very high production costs (see Table I, rows 6, and 12–15) because of its landlocked location and political problems such as the Rhodesian Unilateral Declaration of Independence.[39] While, within a certain price range Zambia's supply curve bends backward,[40] a great fear for its reserve position and a relatively low discount rate[41] make Zambia the most persistent advocate of production cutbacks.[42]

The history of CIPEC since its inception in 1967 confirms the above behavior. Consider, for instance, CIPEC's 1977 attempt to use concerted action to influence copper prices. Zambia, Zaire, and Peru (led by Zambia) agreed on a 15 per cent reduction in output and sales in order to boost copper prices. Chile, the largest producer in terms of output and the strongest in terms of reserves, refused to go along, while Peru was reluctant to take part and joined only after it was accepted that its own cut would be based on capacity rather than production figures. This meant that Peru would have 8 per cent more copper available for export after the cutback than before it; "we are treating it very lightly—a bit of a joke really" a source of Mineroperu, the state mining company, is reported to have said [1, Mar. 3, 1978, p. 6]. The African producers would have trouble matching their 1977 output level, anyway, because of production and transport constraints. They were simply formalizing a situation that already existed. Moreover, Zaire, badly in need for Western financial and political support,[43] implemented a cut-

[38] For more details on Zambia's intransigent dependence on copper, see Panayotou [10, Chapter 2].

[39] Zambia's export and import routes through Angola and Rhodesia are effectively sealed off at present (and for some time to come) and the only exit for its copper is through the congested Zambia-Tanzania Railroad.

[40] Consider, for instance, the following quote from the *Manchester Guardian Weekly* (April 30, 1978): "Zambia one of the world's leading copper exporters produces it for 68 cents and sells it for 59 cents a pound. Though it loses 9 cents a pound Zambia this year will produce all the copper it can; it is almost the only product it has to sell for dollars in international markets and Zambia desperately needs dollars—in part to pay off debts it incurred from running its copper mines at a loss in the past."

[41] Zambia's low discount rate may be inferred from the percentage of government revenues devoted to capital formation (40 per cent compared to 20 per cent by Zaire).

[42] Zambia's advocacy for production cutbacks to raise prices is usually viewed as an attempt to formalize a situation that already exists and to put pressure on other copper producers to agree on similar cutbacks [1, Mar. 3 and Apr. 11, 1978].

back in production, not deliveries, by purchasing copper at the LME to make good of its export commitments. As a result of this incompatibility of interests among CIPEC members, this last attempt to prop sagging copper prices had the same fate as all previous ones.[44] As the *Asian Wall Street Journal* (July 21, 1978, p. 6) put it:

> Last year the CIPEC nations attempted to reduce their marketing 15% to increase prices and profitability. But the attempt was unsuccessful because Chile refused to go along, Zaire's reduction was in production not deliveries, and Peru's was from a theoretical production level. There weren't any ambitious plan discussed at this year's CIPEC session. "CIPEC has been burned in the past by talking big and being unable to deliver..." says one observer.

While it must be clear by now that the benefits from cartelization are too limited and the differences among individual countries too severe to produce an effective agreement for concerted action, for reasons of completeness we briefly refer to another constraint on the ability of CIPEC governments to pursue monopoly pricing. Up to this point we have implicitly assumed that CIPEC governments have absolute control of production and marketing of their own copper. Until quite recently, however, considerable oligopoly power was in the hands of multinational companies who, with varying degrees of horizontal and vertical integration, produced, marketed, and fabricated copper. These companies could deny investment, technology, managerial and technical personnel to (or threaten to reduce purchases from) any country pushing for higher prices and do so by switching to alternative sources of supply. As the dependence on copper and on foreign expertise varies among CIPEC countries, this alone would have produced varying degrees of pressure to forego an agreement or to "chisel."

Today, however, the power of the foreign companies has been considerably reduced by complete or partial nationalization, joint ventures, establishment of national marketing companies, and direct agreements between the governments of producing and consuming countries. In Chile all major foreign-owned companies have been expropriated and in Zaire 100 per cent equity has been acquired by the government while Zambia acquired 51 per cent equity and gradually took over the management of the mines and is now increasing its control over the marketing process. Finally, in Peru, where many developed mines are owned by foreign firms, the government recovers all undeveloped copper properties and exercises increasing control over the industry through the state mining company. Although the CIPEC governments continue to depend with varying degrees on

[43] Zaire owes up to $3 billion to foreign governments and banks, inflation is more than 50 per cent a year and its outlays exceed income by 25 per cent. Moreover, it faces the constant threat of guerilla attacks on its copper-rich provinces from neighboring Angola [1, June 15, 1978, p. 7].

[44] From Appendix Table III it may be seen that during the eight years following the inception of CIPEC (1967) Zaire had the largest (54 per cent) expansion of output among all CIPEC members and Zambia the lowest (5 per cent) while Chile and Peru had more moderate changes: increases of 36 per cent and 14 per cent respectively. During the same period Canada managed to increase its share of the market at the expense of CIPEC and particularly of Zambia; the Canadian mine output alone increased by 80 per cent over the period 1966–74.

the multinationals for technology, for managerial and commercial expertise, and above all for customers, this dependence is not likely to be the binding constraint on their attempts to raise copper prices. The binding constraints are, rather, their inability to command a greater share of the market and their failure to reconcile their conflicting individual interests with the welfare of the group as a whole.

SUMMARY AND CONCLUSIONS

We set out to examine the chances of a successful OPEC-type strategy by copper exporters and obtained a largely negative answer. At best, CIPEC would be able to obtain a short-run gain if it was willing to open its doors to other copper exporting countries. Given, however, sufficient time for adjustment of demand and competitive supply these gains would disappear. In fact, over the long run, CIPEC may suffer substantial losses in market share to non-CIPEC producers (to Canada in particular), and the copper market may be damaged irreversibly by a policy of high or fluctuating prices in pursuit of potential short-run gains. For CIPEC to have any success in the long run it must secure control over 80 to 90 per cent of world copper production which is virtually impossible given the share of secondary copper in world supply, the almost self-sufficient U.S. copper market and the highly elastic (over the long run) Canadian supply. Even if the potential short-run gains were large enough to more than compensate for future losses and for the costs of cartelization, the incompatibility of interests among current CIPEC members would render any agreement ineffective and lead to a highly unstable cartel as, indeed, has been CIPEC's history over the last decade. This does not imply that copper prices will not change in the future but if they do it would not be because of CIPEC action. Our finding that there is no room for monopoly pricing of copper offers a strong indication that for some years to come copper prices will continue to be determined by the forces of demand and supply in a more or less competitive environment. If CIPEC were to attempt an OPEC-type strategy Canada and others in the competitive fringe could increase their market share at the expense of CIPEC members.

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APPENDIX

The price elasticity of demand for CIPEC copper (ε_{DC}) may be calculated from the price elasticity of world demand for copper (ε_{DW}), the price elasticity of non-CIPEC supply (ε_{SN}), and the market share of CIPEC in world copper supply (α_C), according to the following formula:

$$\varepsilon_{DC}=(\varepsilon_{DW}/\alpha_C)-(\varepsilon_{SN}/\alpha_C)+\varepsilon_{SN}\,, \tag{1}$$

where $\partial\varepsilon_{DC}/\partial\alpha_C<0$, $\partial\varepsilon_{DC}/\partial\varepsilon_{DW}<0$, and $\partial\varepsilon_{DC}/\partial\varepsilon_{SN}>0$.

Formula (1) may be derived from the demand and supply functions of CIPEC (D_C and S_C respectively), of non-CIPEC (D_N and S_N) and of the world as a whole (D_W and S_W), plus the corresponding market clearing conditions (for this derivation we follow Takeuchi [15]):

$$D_W=D_W(P),\quad S_W=S_W(P),\quad \text{and}\quad D_W=S_W. \tag{2}$$

$$D_W(P)=S_W(P),\quad D_C(P)=S_C(P),\quad \text{and}\quad D_N(P)=S_N(P). \tag{3}$$

$$D_W(P)=D_C(P)+D_N(P)\quad \text{and}\quad S_W(P)=S_C(P)+S_N(P). \tag{4}$$

By rearrangement and substitution:

$$D_C(P)=D_W(P)-S_N(P)\,. \tag{5}$$

Differentiating (5) with respect to P and multiplying both sides by P/D_C we obtain:

$$\begin{aligned}\frac{dD_C}{dP}\cdot\frac{P}{D_C}&=\frac{dD_W}{dP}\cdot\frac{P}{D_C}-\frac{dS_N}{dP}\cdot\frac{P}{D_C}\\&=\frac{dD_W}{dP}\cdot\frac{P}{D_W}\cdot\frac{D_W}{D_C}-\frac{dS_N}{dP}\cdot\frac{P}{S_N}\cdot\frac{S_N}{D_C}\end{aligned} \tag{6}$$

Since from (3) and (5) we obtain:

$$S_N/D_C=(S_W-S_C)/S_C=(S_W/S_C)-1=(1/\alpha_C)-1\ ,$$

where $\alpha_C=S_C/S_W=D_C/S_W=D_C/D_W$, by substitution equation (6) becomes for formula (1), where $\varepsilon_{DC}\equiv(dD_C/D_C)/(dP/P)$, $\varepsilon_{DW}\equiv(dD_W/D_W)/(dP/P)$, and $\varepsilon_{SN}\equiv(dS_N/S_N)/(dP/P)$.

APPENDIX TABLE I

ESTIMATES OF PRICE ELASTICITY OF COPPER DEMAND

(Absolute value)

Country	Short-run Demand		Long-run Demand		FCB Cross Elasticities		FCB Income Elasticities	
	Banks	FCB	Banks	FCB	Short-run	Long-run	Short-run	Long-run
U.S. (a)	0.34	0.213	2.85	0.900	0.239	1.010	0.332	1.402
U.S. (b)		0.172		0.817	0.204	0.976	0.153	0.732
Britain	0.06–2.21		0.23–2.51					
Germany	—	0.088	0.22	0.192	0.613	1.341	0.453	0.991
France	0.08		—					
Italy	0.23–0.26		—					
Japan (a)	—	0.118	—	0.118	—	—	0.992	0.992
Japan (b)		0.094		0.094	—	—	0.601	0.601
Rest	—	0.218	—	0.925	0.107	0.4561	0.409	1.736

Sources: The Banks' estimates [2] are obtained from Takeuchi [15] while the FCB estimates from Fisher, Cootner, and Baily [7, pp. 583–90].

Note: All FCB statements corresponding to Britain, Germany, France, and Italy refer to Western Europe as a whole. For U.S. (a) and Japan (a) the index of economic activity is represented by the index of construction, while in U.S. (b) and Japan (b) by the index of industrial production.

APPENDIX TABLE II

ESTIMATES OF PRICE ELASTICITY OF COPPER SUPPLY

Country	Excluding Copper from Scrap				Including Copper from Scrap[a]			
	Short-run		Long-run		Short-run		Long-run	
	Banks	FCB	Banks	FCB	Banks	FCB	Banks	FCB
Chile	0.22	0.11	1.44	0.40	0.18	—	0.37	—
Zambia	—	0.07	—	0.07	—	—	—	—
Peru	0.42	—	3.41	—	0.15	—	0.71	—
Zaire	0.10	—	3.69	—	0.07	—	0.18	—
U.S.	0.25	0.45	0.71	1.67	0.47	0.42[b]	0.77	0.31[b]
Canada	0.18	0.19	42.24	14.84	0.10	—	1.23	—
Rest	—	0.96	—	1.68	—	0.25	—	0.16

Sources: The Banks' estimates [2] were obtained from Takeuchi [15]; and the FCB's estimates from Fisher, Cootner, and Baily [7].

[a] While the Banks' estimates refer to total (primary plus secondary) copper supply, the FCB's estimates refer to secondary copper alone.

[b] Refers to old scrap (short-run elasticity for new scrap 1.48).

APPENDIX TABLE III

WORLD MINE PRODUCTION OF COPPER

(In thousand metric tons)

	U.S.A.	Canada	Chile	Peru	Zambia	Zaire	World (excl. CPEs)	Centrally Planned Economics
1950	825	240	363	30	297	176	2,287	—
1951	842	245	381	32	319	192	2,384	—
1952	840	234	409	30	330	206	2,443	—
1953	841	230	361	35	373	214	2,459	—
1954	758	275	364	38	398	224	2,485	—
1955	906	296	433	43	359	235	2,731	—
1956	1,002	322	488	46	404	251	3,031	—
1957	986	326	479	55	436	243	3,091	—
1958	888	313	465	52	400	238	2,957	—
1959	748	359	545	50	543	282	3,153	—
1960	980	399	532	184	576	302	3,617	625
1961	1,057	398	547	198	575	295	3,714	679
1962	1,114	415	586	165	562	297	3,811	744
1963	1,101	411	601	180	588	271	3,875	749
1964	1,131	442	622	176	632	277	3,997	850
1965	1,226	461	585	180	696	289	4,152	917
1966	1,296	459	637	176	623	317	4,315	980
1967	866	556	660	186	663	322	4,058	1,015
1968	1,093	575	658	214	685	326	4,418	1,055
1969	1,401	500	688	199	720	364	4,821	1,083
1970	1,548	613	686	203	684	386	5,128	1,168
1971	1,381	654	708	213	681	406	5,183	1,277
1972	1,510	720	717	217	718	437	5,718	1,338
1973	1,558	824	735	220	707	490	6,148	1,443
1974	1,449	826	902	213	698	496	6,259	1,598
1975	1,280	713	793	177	677	460	5,718	1,673

Sources: 1950–70 (excluding centrally planned economies)=Takeuchi [15, p. 9] and 1970–75=*Mindeco Mining Yearbook of Zambia.* For centrally planned economies, 1960–69=UNIDO [17, p. 12], and 1969–75=*Mindeco Mining Yearbook of Zambia.*

Note: — indicates that the data were unavailable to the author.