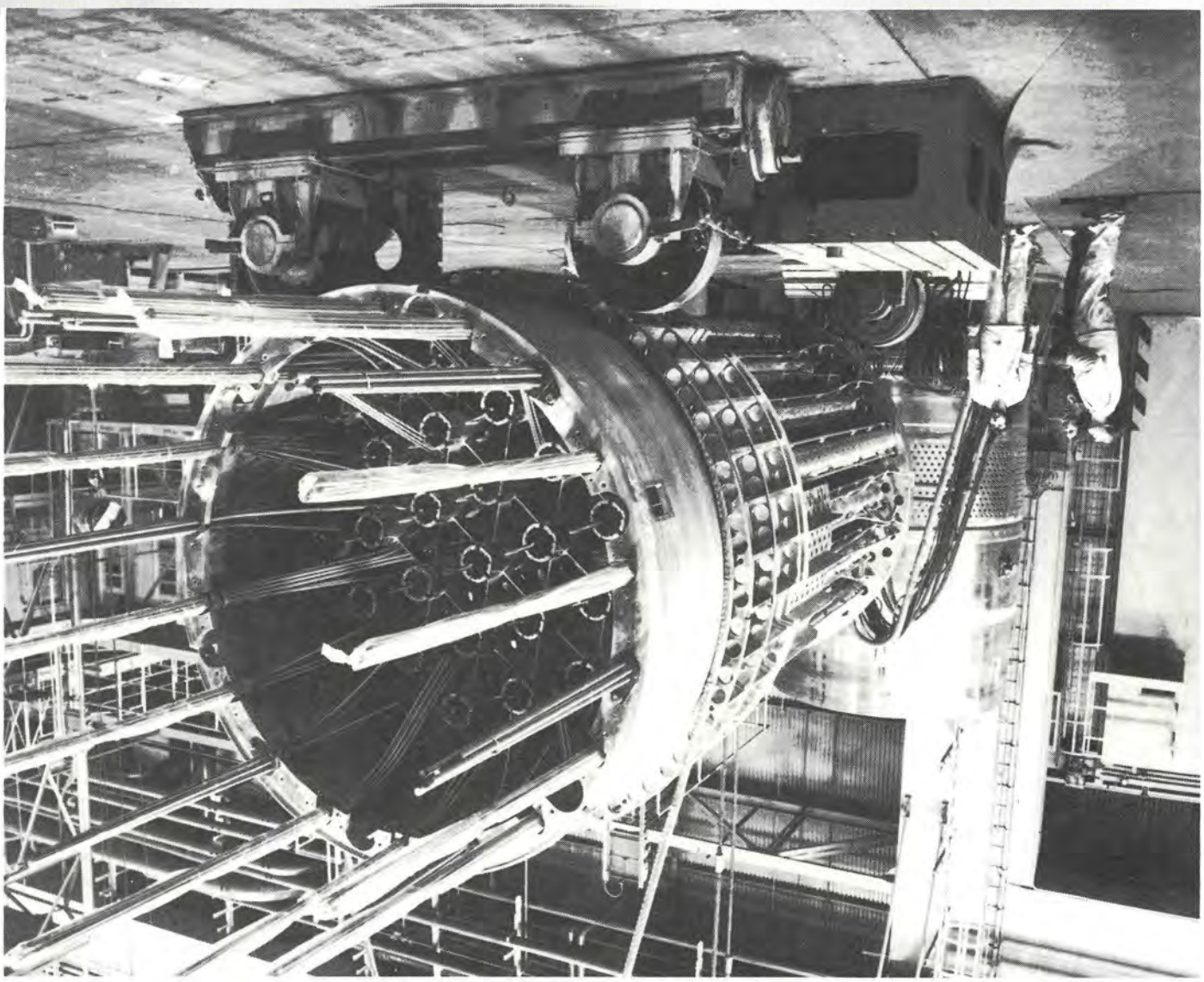


The Stojlenskoe open pit iron ore mine in the Kursk Magnetic Anomaly, the world's largest iron ore deposit. (Top).
Production of nuclear-power plant equipment at the SKODA Works, Plzen, CSSR.

World raw material markets until the year 2000 – implications for Eastern Europe

By István Dobozi

This study examines a number of major aspects of the world market for minerals. Based on this it also discusses perspective possibilities and conditions of resource supplies for Eastern Europe from CMEA (Council for Mutual Economic Assistance), as well as from non-CMEA sources. Continuing difficulties in resource imports from CMEA sources is projected. The cost advantages of these imports relative to non-socialist imports and to the development of domestic mining will, in general, substantially diminish, and in certain cases even discontinue. The study concludes that for several non-fuel minerals and energy sources a rise in the share of non-socialist countries in the imports of East European countries will become necessary in the period until 2000.

István Dobozi is Professor of Economics and Head of the Institute for World Economics in Budapest, Hungary. He is a member of the Editorial Advisory Board of RMR.

Adequacy of mineral commodities and energy sources

For the mineral reserves and energy sources examined in this article, we can state unambiguously that in 20 years the state of proven reserves [1] will not constitute a physical limit to the satisfaction of the world demand for raw materials. The case studies[2] corroborate those forecasts which expect the world's proven reserves to keep pace with the expansion of raw materials consumption.

According to the 1979 survey of OECD, the world's cumulative demand for raw materials between 1976 and 2000 could be satisfied – with a few exceptions – even if the proven reserves remained at their 1976 level.[3] This is all the more reassuring because proven reserves usually grow *pari passu* with, or even at a faster rate, than consumption. (See Table 1).

In the case of any of the minerals and energy sources examined one can hardly conclude that there is a general problem of physical scarcity of minerals for the future. As a result of improved prospecting techniques, both the quantity of reserves of certain minerals and their statistical lifespan may increase until the year 2000. With the development of deep-sea mining, the reserves and expected statistical lifespan of several minerals, manganese, copper, nickel, cobalt, etc, may increase still in our century – considerably. Of the mineral resources not reviewed in this study, just a few minerals, e g, zinc, asbestos, exhibit relative shortage problems.

Expected changes in world demand

In the two decades to come, the world consumption of mineral raw materials and energy sources will rise at a lower rate than they did during the preceding 15 to 20 years. (For a few minerals, see the forecasts in Table 2.) The measure of the fall in growth rates varies by products and geographical regions. Their fall will be largest in the developed market-economy countries, while more moderate in the socialist countries. The smallest decline in the growth rates of most minerals will occur in the developing countries. It is a consequence of divergent growth rates that the share of developing countries in world consumption will increase in the case of all minerals and energy sources. As regards the developed socialist countries, their share will slightly rise in most cases. The developed market-economy countries' weight in the world consumption of all commodities under review will exhibit a significant setback until 2000.

The fall in the growth rates of perspective global consumption can be traced back in general to the following causes:

- lower projected growth in world GNP
- modification of the structure of economic activity in the industrially developed countries towards the less raw material intensive sectors
- resource-saving technological developments that alter the efficiency with which raw materials and energy sources are processed and utilized in the production of final goods
- substitution among raw material inputs in response to relative price movements and relative rates of technological progress.

Expected changes in world output

The growth rate of the output of raw materials and energy sources just as that of their consumption will decline in the case of all commodities under review. But the measure of the fall in growth rates will vary by the individual commodities. As regards the distribution by group of countries of the output of non-fuel minerals and energy sources, the dominant trends will be the rise – in some cases a very significant one – in the share

of developing countries in world output. (See Table 3).

Of the minerals examined it is only uranium which constitutes an exception in this respect, with its output likely to expand most dynamically in the developed market-economy countries.

In the European socialist countries it is, presumably, only natural gas that can increase its share of world output.

For copper, bauxite, phosphate and petroleum the share of the European socialist countries is likely to fall considerably, while no major changes can be predicted for other minerals.

Expected changes in world market supply

The projected fall in the growth rate of world consumption influence the world market supply of several minerals and energy sources in a similar direction. As evidenced by a part of the case studies, the growth rate of world exports

Table 1

Long term changes in the world reserves of selected minerals 1950, 1965/66, 1975/76 and 1977. (Mt)

	Copper[1]	Lead[1]	Tin[1]	Zinc[1]	Bauxite	Chromite[2]	Molybdenum[1,3]	Tungsten[1]
1950	100.0	40.0	6.9	70.0	1 400	n a	n a	1.9
1965-66	195.0	93.4	n a	75.3	5 964	2 414	2.2	n a
1975-76	408.2	150.0	10.2	135.3	17 272	2 841	6.0	1.8
1977	456.0	124.0	10.2	150.0	n a	n a	9.0	2.0

Notes: n a = not available [1] metal content – [2] Cr_2O_3 content – [3] Western world only

Source: *Interfutures, Final report, Facing the Future: Mastering the Probable and Managing the Unpredictable.* Paris 1979, OECD, p. 46.

Table 2

Historical and projected rates of growth in world demand for selected non-fuel minerals[a]

(per cent)

	Historical[1]		U S Bureau of Mines[2]		World Bank Staff[1]		Malenbaum[3]	
Aluminium	7.3	(1960-76)	5.2	(1975-2000)	6.7	(1974/76-90)	3.0	(1975-2000)
Refined copper	3.9	(1955-77)	4.0	(1975-2000)[b]	3.4	1977-90)	2.1	(1975-2000)
Iron ore	3.6	(1960-76)	2.8	(1973-2000)	3.2	1976-90)	2.1	(1975-2000)
Nickel	6.5	(1950-74)	3.5	(1975-2000)	5.1	(1976-90)	2.1	(1975-2000)
Tin	1.0	(1955-76)	1.5	(1973-2000)	1.3	(1974/76-90)	1.7	(1975-2000)

Notes:

[a] Annual averages over the periods indicated.

[b] World demand for primary copper (excluding scrap). This is a composite of a 4.5 per cent projection from 1975 to 1985 and 3.7 per cent from 1985 to 2000.

Sources:

[1] Data from internal World Bank Staff study, data exclude centrally planned economies.

[2] Copper forecast: H S Schroeder, *Copper* (Bureau of Mines, June 1977), p. 14;
Nickel forecast: J D Corrick, *Nickel-1977* (Bureau of Mines, July 1977), p. 15;
Aluminium, iron ore and tin forecasts: *Mineral Facts and Problems* (Bureau of Mines, 1976), pp. 60, 543 and 1 137.

[3] Wilfred Malenbaum, *World Demand for Raw Materials in 1985 and 2000* (New York, 1978, McGraw Hill), Table 5a.

Adapted from:
Raymond F. Mikesell, *New Patterns of World Mineral Development*, Washington, 1979, British-North American Committee, p. 78.

will fall in the coming two decades compared with the historical growth rate. Substantial will be the decrease in growth rate, for example, of phosphate, iron ore, and petroleum, while world exports will rise at an accelerating rate in the case of bauxite, natural gas, uranium and coal. Moreover, the export quota of world output will exhibit an increasing trend in the case of several minerals e g, coal, uranium, iron ore, natural gas.

The share of developing countries in the world export of most minerals and energy sources is expected to rise. Likely exceptions to this trend will be only coal and uranium where the developed market-economy countries will increase their weight in world exports. As a characteristic trend may be predicted the declining share of European CMEA countries in the world export of practically all materials and energy sources. In the case of coal, for example, the share of the European CMEA countries, Soviet Union and Poland, in world exports is expected to fall from 29 per cent in 1979 to about 17 per cent by 2000. A similary significant setback is likely to ensue in the case of petroleum and iron ore. The declining trend of the export share of CMEA countries foreshadows the presumably aggravating quantitative constraints to the prospective raw material and energy imports from these countries.

Expected changes in mineral investments

Despite the expected fall in the growth rate of world output, anticipated capacity expansion will involve extremely large capital requirements. (For a few commodities, see Table 4.) Owing to the fast-rate increase in project sizes,

Table 3

Distribution by groups of countries of the world output of selected minerals and energy sources
(per cent of world output)

		Developed market-economy countries	Developed centrally planned economies	Developing countries
Copper	1970	41.7	16.7	41.4
	2000	23.3	8.7	68.0
Iron	1970	39.1	29.4	31.5
	2000	22.9	34.4	42.7
Petroleum[1]	1970	25.7	16.1	58.2
	2000	20.2	14.7	65.1
Natural gas[1]	1970	71.4	21.6	17.0
	2000	38.8	36.5	24.7
Coal	1970	46.7	29.5	23.8
	2000	44.8	25.0	30.2
Nickel	1970	50.4	17.7	31.9
	2000	16.5	19.0	64.5
Zinc	1970	58.5	17.0	24.5
	2000	64.0	–	35.2
Lead	1970	50.0	23.5	26.5
	2000	43.2	23.0	33.8

Note:

[1] Coal-equivalent

Source:

On the basis of W Leontief, A P Carter, P A Petri: *The Future of World Economy, A United Nations Study*, New York, 1977, Oxford University Press, p. 46.

Table 4

World capital expenditures for estimated additional capacity requirements for selected minerals, 1977-2000[a]
(GUSD)

	Total	In developing countries
Bauxite	6.9	5.2
Alumina	24.4	6.1
Aluminium	76.6	17.6
Subtotal	**107.9**	**28.9**
Copper	58.0	29.0
Nickel	12.5	5.0
Iron ore	98.2	31.4
Tin	1.7	1.4
Total	**278.3**	**95.7**

Note:

[a] Excludes capital outlays for pollution abatement and exploration. Calculated in 1977 USD. All capital expenditures for years other than 1977 were converted to 1977 USD by applying the US implicit GNP deflator.

Source: Raymond F Mikesell, *op. cit.*, p. 11.

to the deterioration of geological circumstances, to growing environmental and infrastructural expenses, the capital-intensity of mineral mining experienced a world-wide rise in the 1970s. This trend is likely to continue in the two decades to come. Average annual investments, for example, in the world copper industry will rise from 1.1 billion USD in the period 1977-1985 to 3.2 billion USD, between 1985 and 2000. According to a combined estimate for five basic minerals, copper, aluminium, iron ore, nickel, tin, total investment need will increase from about 2 billion USD as the annual average of the past few years to 12.5 billion USD by the end of the century (calculated in 1977 USD). Investments will exhibit a particularly fast upswing during the 1990s.[4]

As shown in Table 5, the share of the extractive industries in total capital stock tends to increase in most regions between 1980 and 2000. The proportion of investment that is devoted to extraction is expected to rise at the fastest rate in the European CMEA countries and the developing countries between 1970 and 2000.

The total capital required to meet projected world demand for minerals is likely to be available. In the foreseeable future, the main problem may be the same as it was in the 1970s, notably that – in view of the great economic and political risks involved – the international extractive capital is reluctant to invest in the developing countries. As a result of the significantly increased risk and instability as well as the unsettled nature of co-operation relations between the governments of host countries and foreign companies, both exploration activities and investment expenditures by international mining firms in Third World countries have declined substantially in recent years. Owing to the inadequate indigenous accumulation capability of the developing countries, this tendency could not be stemmed. The shift in the geographical orientation of international mining capital is clearly reflected in the changes in American extractive industry investments abroad. As shown in Table 6, the book value of US direct investments in the Third World in mining and smelting (at current prices). Their share in these direct foreign investments fell from 40 per cent in 1972 to 32 per cent in 1977. At the same time, investments in the mining industry progressively increased in the developed market-economy countries and in the United States itself.

Table 5

Capital stock used in resource extraction
(per cent of total capital stock)

	1970	1980	1990	2000
Developed market economy countries	1.05	1.56	2.31	2.88
Developed socialist countries	2.45	5.37	5.36	6.63
Developing countries	3.67	5.02	4.69	8.36

Source: Wassily Leontief *et al., op. cit.*, p. 48.

Table 6

Book value of US direct foreign investment in mining and smelting 1966-1977

	Developing countries		Developed countries		Developing countries
	Value (MUSD)	Change from previous year (per cent)	Value (MUSD)	Change from previuos year (per cent)	as per cent of total
1966	1655	a	2328	a	42
1967	1791	8.2	2658	14.2	40
1968	1962	9.5	2875	8.2	41
1969	1970	0.4	3029	5.4	39
1970	2119	7.6	3286	8.5	39
1971	2218	4.7	3569	8.6	38
1972	2267	2.2	3400	4.7	40
1973	2265	0.1	3773	11.0	38
1974	1784	21.2	4007	6.2	31
1975	2150	20.5	4398	9.8	33
1976	2309	7.4	4750	8.0	33
1977	2265	1.9	4802	1.1	32

Note:
a – No entries here since new series began with 1966.

Sources: 1966 through 1975: *Selected Data on US Direct Investment Abroad, 1966-1976*, Bureau of Economic Analys, US Department of Commerce (1977). 1976 and 1977: US Department of Commerce, *Survey of Current Business.*

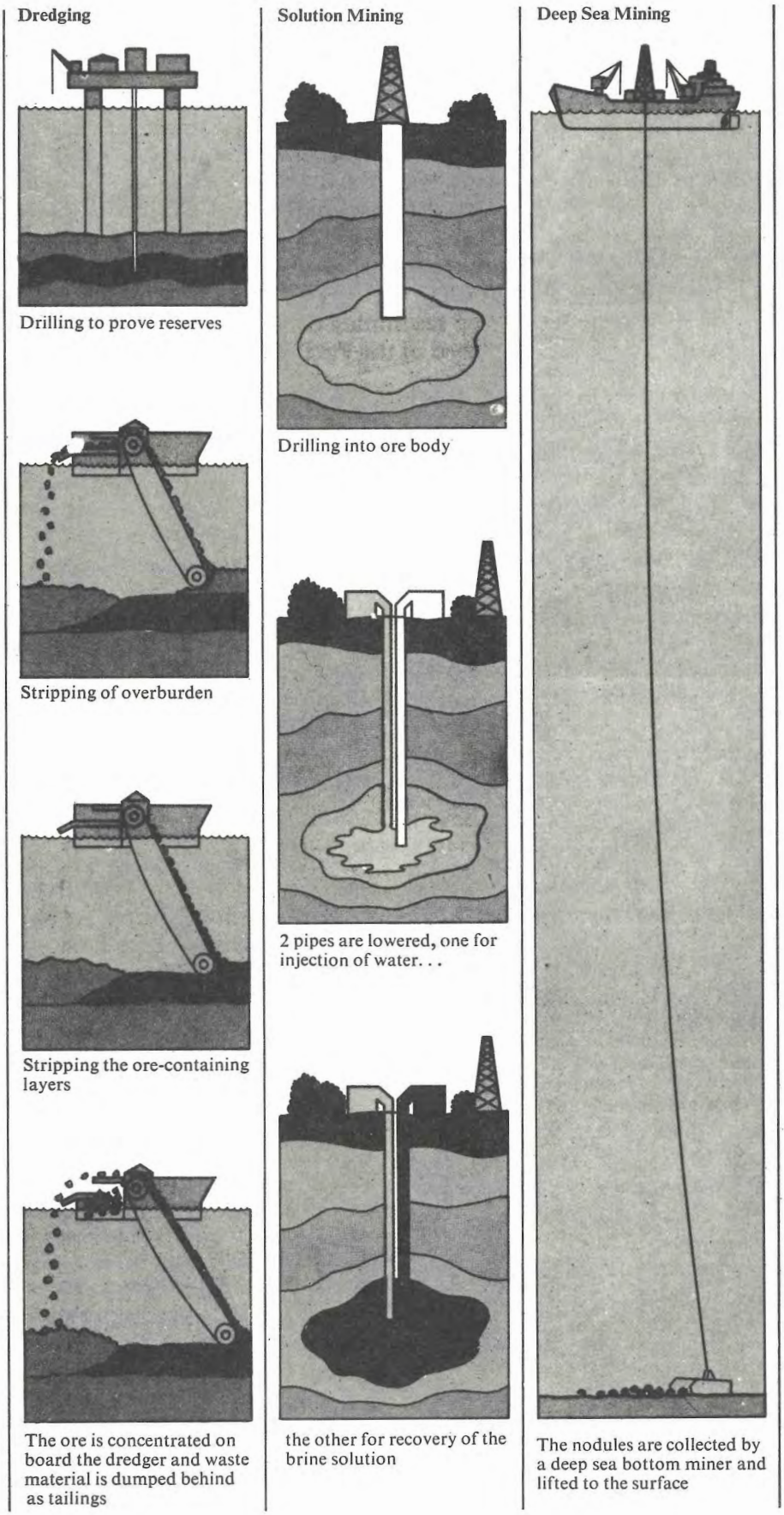
The leading mining TNCs are investing heavily in sophisticated exploration and extraction technologies. Their aim - to counter the growing influence on world mineral markets by state enterprises from the developing countries.

To meet the expected world demand for minerals and energy sources until 2000, it is essential to raise investments in the extractive industries, including exploration activities of the developing countries at a rapid rate. This is a pre-condition for the satisfaction of the anticipated world demand for several commodities. In the case of bauxite mining, for example, about three-fourths of the capital needed for a world-wide capacity expansion will arise in the developing countries between 1977 and 2000. This proportion will amount to 50 per cent for copper and close to one-third for iron ore. These investment needs cannot be met without a massive inclusion of external capital resources.

Expected changes in demand-supply situation

The case studies do not forecast the emergence of a persistent world market shortage of most commodities in the two decades to come. An exception may only be petroleum, for the second half of the 1990s, in case of which, owing to a possible unfavourable coincidence of circumstances, a relative shortage or a tight market situation may evolve.

Traditionally characteristic of the world market for several commodities in the long run is the propensity for excess supply. It is expected that this feature will persist and possibly strengthen in the future in the case of a number of commodities, primarily because the organizational structure of several mineral industries has undergone a substantial transformation over the recent years. The weight of state enterprises, particularly in the extractive industry of the developing countries, has substantially grown and will further expand in the future. A possible consequence of this is that supply can react less flexibly than before to changes in demand and prices. The profit-maximization efforts of private companies may be of second-



ary importance to the government-controlled state enterprises with their objectives to maintain or expand employment and to increase their export revenues.

This propensity for over-production may, in the long run, further be strengthened by certain mechanisms already operating or envisaged in the UNCTAD Integrated Programme for Commodities in the Lomé Convention, or in other forms of international market stabilization, which further weaken the orientating function of market signals stemming from the demand side. As a result of cyclical factors, conscious cartel tactics, unexpected international conflicts, protracted strikes, etc, short-term shortage situations may, or will in fact, certainly continue to develop from time to time.

The above statements on global demand-supply pattern do not exclude the emergence of lasting shortages or surpluses at the regional or national level. For example, the CMEA market is likely to increasingly break away, with respect to several commodities, from the world market. In the past, within the CMEA integration, shortages occurred in several commodities e g, aluminium and coking coal of which there was an over-supply in the world market, or which had a balanced market situation. The increasing difficulty within the community, coupled with the limited hard currency purchasing power of the CMEA countries in relation to world markets, may create a sustained regional disequilibrium between demand and supply even under conditions when there is over-supply in the world market, or when a balanced market situation prevails. Such a tension between latent demand and demand underpinned by purchasing power is also sure to emerge in certain groups of developing countries as net importers of mineral commodities and energy.

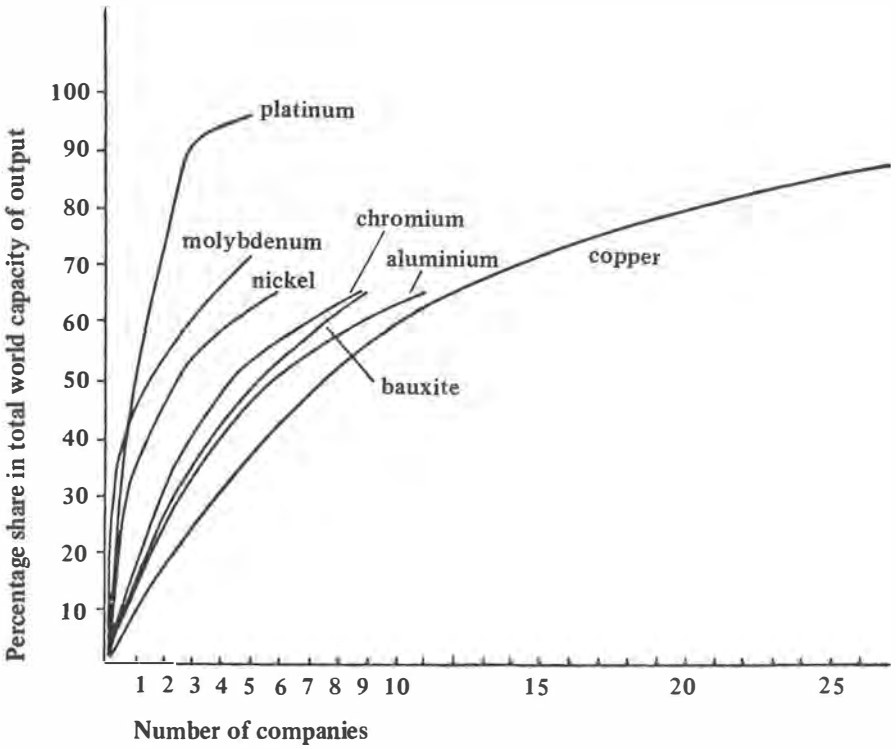
Anticipated changes in the market structure

Typical of most of the sectors of capitalist extracting industry is invariably the oligopolistic pattern, that is, a high level company concentration on the supply side. The usually vertically integrated oligopolistic companies have a substantial weight not only in the extraction of a given mineral raw material, but also in the field of processing, transport, marketing and developing new technologies.

As shown by Figure 1, ten or fewer companies are responsible for producing at least 60 per cent of the non-socialist world output of commodities in the case of all minerals. It also demonstrates that the degree of company concentration shows wide disparities in individual cases. The oligopolistic concentration is much smaller, for example, for copper than for

Figure 1

The degree of oligopolistic firm concentration



Note:
Bauxite: output in 1976; aluminium: capacity in 1974; copper: refining capacity in 1974; chromium: mining capacity in 1974; nickel: metal output in 1976; molybdenum: mining capacity in 1974; platinum: metal capacity in 1974.

Sources: On the basis of *Interfutures, op. cit.* and Wolfgang Gluschke, Joseph Shaw, Bension Varon, *Copper: The Next Fifteen Years, A United Nations Study*, Dordrecht–Boston–London, 1979, D. Reidel Publishing Company.

platinum or molybdenum. But for many others e g, bauxite, petroleum, copper, oligopolistic company concentration shows a declining trend over time. This process is due to several factors:

- the powerful drive of nationalization and state control in the past 10-15 years, particularly in the developing countries, as a result of which new state enterprises have been established and have increased their weight mainly in the phase of extraction
- vertical integration processes setting out of manufacturing, as a result of which many "independent" enterprises have come into being and penetrated the extractive stage.

As regards future development, a gradual advance towards more competitive market structures is likely to occur for several reasons. As a result of the continuing nationalization and controlling measures of host countries, the number of state and semi-state extractive enterprises will grow substantially in the future. Owing to the disturbances and crisis phenomena in the mineral and energy markets in the 1970s, there is an increased tendency for supply-security considerations to come to the fore, for new state enterprises to be established in the developed capitalist countries, too. The endeavour to ensure a greater security of supplies will, in all probability, accelerate the vertical integration processes stemming from the manufacturing industries, and will act towards establishing a self-controlled raw material base. As a result, the number of extracting industry enterprises and the competition among them for the markets are likely to further increase.

During the past 10 to 15 years, important changes have also taken place in the sales forms of individual commodities in the world market. The weight of the turnover transacted in the framework of long-term 10-15-20 years, supply contracts has greatly increased in the international trade in minerals. At the same time, there is a declining tendency – in the case of most commodities – in the proportion of intra-company trade, and especially of free market sales. Currently, 75 to 80 per cent of international trade in non-fuel minerals is transacted in "closed markets", ie within the framework of intra-company turnover and long-term supply contracts. The proportion of free-market trade, eg, in non-ferrous metals, is only 10 to 15 per cent.

Perspectively, a high share of closed markets is expected to persist, and indeed, its further rise may be predicted in certain cases mainly for supply-security reasons and/or for ensuring controlled outlet markets by the producers. Especially the weight of these long term supply contracts may increase in the case of which closer cooperation relations, in crediting, technological field, etc, are established between the producer and the consumer. In order to increase the long term stability of resource supply, the duration of supply contracts is expected further to rise, and agreements concluded for longer periods, 15, 20 or 25 years, will become more frequent. As a result of these developments, it is still unlikely that in the foreseeable future free markets as significant supply sources can be taken into account. These markets will increasingly become scenes of increasing speculation, with relatively marginal quantities being exchanged on them.

Estimated formation of world market prices

The forecastning of world market prices entails a great many uncertainties and therefore respective conclusions, especially numerical estimates, have to be handled with due caution. The price formation of non-fuel minerals and energy sources until 2000 and the terms of trade between these commodities and the manufactured products will be determined by several forces acting in contradictory directions.

The following factors will act towards *rising* long term *prices* of non-fuel minerals and energy sources:

- A continuation of world inflation, though a lower rate than in the 1970s, of about 6 to 7 per cent annually.
- As a general trend, extension of the marginal fields of mining towards poorer-quality and less accessible deposits. This process is, partly, the continuation of a long term tendency and, partly, the consequence of the fact that consumer controlled mineral reserves even of a poorer quality have, for supply-security reasons, been "revalued" to a certain extent. But this trend does not equally assert itself in the case of all commodities. No sizeable quality deterioration is expected in many of them under review. For example, the copper ore of a 1.03 per cent copper content, constituting the current world average, will gradually fall to about 0.9 per cent by 2000.
- Rapid growth in the expenditure on environmental protection and an expected rise in the ratio of these expenditures to total costs, specially in the industrially developed countries. The share of expenditure devoted to environmental protection in the United States amounted in 1977 to only 2.9 per cent of private investments in the extractive industries (the average share in manfuacturing was 7.9 per cent), but to 19.1 per cent in ferrous and to 16.1 per cent in non-ferrous metallurgy.
- A rise in the prices of energy sources, particularly of oil, faster than the average price rise in non-fuel minerals, which raises the production costs of the energy-intensive mining sectors.
- The operation of the cartels of the producing countries, which may cause in certain case and under favourable conditions, a moderate long term price rise. In the case of petroleum, the governmental producer cartel is a significant price raising factor also in the long run. Of the commodities examined by us, it is, besides petroleum, bauxite, iron ore, copper

and phosphate for which such inter-governmental producers cartels of the exporting countries are operating, but so far they have not succeeded in attaining any appreciable long term price rise.

- The international commodity agreements to be established within the framework of the UNCTAD Integrated Commodity Programme will presumably perform, along with their price stabilization function, a type of resource transfer function (transferring resources from the consumer to the producing countries), therefore the commodity agreements will exert a moderate price raising impact.

In contrast, several factors will exert their effects towards *moderating* the rise in *prices* or reducing them. They are as follows:

- The anticipated, relatively significant, long term decrease in the growth rate of world demand for non-fuel minerals an energy sources, as a result of the moderation of the GNP growth rate of the major consumer countries.
- Moderation of the growth rate of demand for minerals and energy sources in the industrially developed countries, as a consequence of the structural transformation of the economy of these countries. In the last two decades the structural shifts towards the less raw material intensive sectors will continue in the developed market-economy countries and virtually start in the socialist countries. This movement will have a moderating effect on specific raw material intensity of GNP.

- A similar effect will be exerted, also from the demand side, by the efforts made both by governments and the private sector to rationalize non-fuel mineral and energy management, to improve specific consumptions with measures such as: material- and energy-saving product design, miniaturization, substitution, influencing consumer behaviour by economic and administrative methods.
- There is no conclusive reason to assume that technological development during the period under review will not exert the same cost-reducing effect from the supply side as it did in the past. Despite the long term trend for deteriorating quality, falling ore grades, of many non-fuel minerals, the real prices of most of these commodities did not exhibit a rising tendency, on the contrary, decline was the typical price trend. In the fields of extraction, transport and processing, technical development did more than offset the cost increment potentially arising from the deteriorating quality of non-fuel minerals.
- There are efforts to counterbalance the cost-raising tendency of a deteriorating raw material quality and of a more difficult accessibility by increasing the complexity of extraction, by a more intensive utilization of by-products with improved separation and recovery. There are examples, e g copper, to prove that the potential cost increment arising from the exploitation of lower grade ores can be compensated for by the increased recovery of by-products from complex multi metal deposits.
- An advance towards more competitive market structures with the reduced price control by global corporate oligopolies. As a result, a market competition, sharper than hitherto, can be expected on the supply side.

As a result of the forces acting for and against price rises, real prices are likely to increase up to 2000 in the case of non-fuel minerals and energy sources examined, except for bauxite. The increase in real prices is due, in almost all cases, mostly to a rise in the real costs of the incremental expansion of production capacities. The greatest price rise is expected in the case of petroleum, where the rise in the marginal costs of production is associated with price-maintaining and price-raising power of an effective producer cartel. The OPEC will be able, as we assume, also in the period under review to turn the presumably occurring, or engineered, "mini-crises" of a political nature to the advantage of price rises, as it did during the 1970s. A significantly more moderate price rise may be predicted for coal, copper, iron ore and phosphate rock. Table 7 provides numerical estimates of the projected world market price changes for selected non-fuel minerals and energy sources. Owing to the many uncertainties, caution is recommended in the use of these estimates.

Trends of technological progress in mineral mining

Technological progress in the past has been rather fast in the extraction, transport and processing of non-fuel minerals and energy sources. Rapid development of the technologies of extraction made it possible to counterbalance the cost-increasing effects arising potentially from the long term tendency of deteriorating raw material quality. This is revealed by the long term declining trend in the past of the real prices of most minerals amidst the powerful drive towards lower grade raw materials.

As Table 8 shows, in the United States, for example, where during the post World War II period the geological conditions of extraction generally further worsened significantly, labour productivity increased during most of the 1950-1975 period at a faster rate in the extractive industry than in manufacturing. Contrary to manufacturing, the number of employed in the extractive industry fell. A trend contrary to what was experienced in labour productivity was typical of capital intensity of production in the two sectors, which rose in the extractive industry and fell in the manufacturing industry throughout the whole period. The average annual growth rate of depreciation costs per unit of production value was in the period under review identical in both sectors, which roughly means that the long term rate of the replacement of fixed capital was the same in both sectors, in other words, technological progress was approximately of the same pace.

The case studies suggest that technological progress will continue to be of a fast rate in the fields of exploration, extraction, transport and processing of non-fuel minerals and energy sources in the next two decades, too. The new methods of localizing mineral deposits, photogeological mapping by satellites, radar examination in depths of several hundred meters, seismic waves generated by explosions and the application of computerized valuation methods in exploration etc, will gain world-wide application in the next two decades.

Technological innovation will be given a new boost in non-fuel and energy extraction and processing by the endeavour aimed at decreasing specific resource consumption, more effective environmental protection, increased utilization of poor quality and multimetal deposits, etc. The complex mechanization and automation of the various productive operations will continue in extraction. Some assessments indicate that in several sectors for most mining equipment the optimum size may have already been developed; future improvements in production techniques will have to rely more on greater mobility and versatility of machines than on larger units. Future underground mining methods will probably show a trend toward systems which allow mass production and extensive mechanization. One example of this is in drilling technology, which will increasingly turn to longer

Table 7

Projected changes in the world market prices of selected non-fuel minerals and energy sources 1977-2000
(current USD, in brackets in 1977 USD)

	1977[1]	1980	1985	1990	2000
Iron ore (USD/t)	21.6	22.5	37.2	51.6	
Copper[2] (USD/t)	1310	1653 (1366)	3527 (2182)	4740 (2299)	
Tin[2] (USD/t)	4.86	5.30 (4.39)	7.35 (4.55)	9.50 (4.61)	
Nickel[2] (USD/kg)	520	599 (496)	1031 (639)	1250 (606)	
Bauxite (USD/t)	30.8	39.8 (32.9)	53.2 (32.9)	67.8 (32.9)	(32.9)
Aluminium (USD/t)	1.13	1.52 (1.26)	2.03 (1.26)	2.59 (1.26)	
Manganese (USD/t)	1.48	1.60 (1.33)	1.89 (1.02)	2.03 (0.98)	
Lead (USD/kg)	0.62	0.75 (0.62)	1.09 (0.67)	1.50 (0.73)	
Zinc[2] (USD/kg)	0.59	0.85 (0.66)	1.25 (0.77)	1.73 (0.85)	
Phosphate rock (USD/t)	30.5	40.0 (33.0)	58.0 (36.0)	78.5 (38.0)	154.1 (43.8)
Petroleum	120	200 (164)	– –	500 (265)	750 (400)
Coal[3] (USD/t)		(70.0)	(77-80)		(105-125)

Notes:

[1] 1977 actual data

Sources: *Price Prospects for Major Commodities*, Vol. IV: *Metals and Minerals*, Washington, 1978, IBRD, and own estimates.

holes in combination with the use of greater borehole diameters. The main attention in blasting will be given to achieving utmost fragmentation.[5]

In smelting and refining, the research and development efforts will be concentrated on the minimization of energy consumption and the development and adoption of environment protecting technologies enabling an improved separation and recovery of by-products; the share of hydrometallurgy is likely to grow at a relatively fast rate because of mounting concern for the protection of environment and widespread interest in exploiting lower grade and non-sulphide ores. The specific investment costs of hydrometallurgy are lower than those of the conventional pyrometallurgy, and hydrometallurgy can be operated more economically even at smaller capacity. In the case of copper, for example, the proportion of hydrometallurgy may increase from the present 10 per cent to 15 to 20 per cent by 1990.[6]

Significant technological progress may be prognosticated for the coming two decades in deep-sea mining. This sector of mineral mining is still largely in the stage of research and development, and most of the technologies worked out so far are of a pioneering character and less suitable for mass production. Despite rapid technological progress towards techniques enabling mass production, deep-sea mining is unlikely to influence significantly the world market processes of copper, nickel, manganese and cobalt. This is, of course, also connected with the largely unresolved problems of the Law of the Sea. By 1990, deep-sea copper extraction is expected to reach 450 kt, accounting for only 2 per cent of the then prevailing world demand.

In the 20 years to come, rapid changes will presumably occur in the energy technologies. In coal consumption, several significant innovations will be implemented: smokegas treatment, fluidized bed combustion system, liquid extraction, magneto hydro-dynamic power generation, etc. Considering that synthetic fuels produced by the existing methods of liquefaction and gasification of coal are not competitive, intensive world-wide research and development efforts are being made to improve conversion technologies.

As regards nuclear technologies, the role of the lightwater reactors will somewhat decline up to the turn of our century, but their share will still remain predominant at about 80 per cent, in world nuclear power-plant capacity. In the perspective, the share of both the gas-cooled graphite-moderated and the advanced gas-cooled reactors will diminish. The high temperature gas-cooled graphite-moderated reactor type is still in an experimental stage. If the development of this reactor type proves succesful, more of them will be built in the industrially most developed countries, and their share in nuclear power plant capacities is likely to rise by the end of this century. The significance of pressurized heavy-water moderated reactors will increase by 2000, and the share of heavy-water reactors in nuclear power capacity may reach 7 per cent. From the data of the reactors being constructed or designed, it may be concluded that the commercial expansion of breeder reactors will be relatively substantial until 2000. But at the beginning of the 1990s, the share of the electric energy produced by breeder reactors will be only around 1 to 2 per cent, and even if we assume a very rapid expansion of capacities, it is unlikely that the share of the electric energy produced by breeding reactors in the overall electric energy produced by the world's nuclear power plants will exceed 5 to 8 per cent at the close of this century.

Perspective possibilities and conditions of supplies from CMEA sources

Most of the case studies project difficulties in raw material and energy imports from CMEA sources until 2000. The general CMEA-level shortage of these commodities will further increase, and they will become even harder commodi-

Table 8

Average annual growth rates of selected economic indicators in US extractive industry (I) and manufacturing industry (II)
(per cent)

	1950-1975		1950-1960		1960-1970		1970-1975	
	I	II	I	II	I	II	I	II
Net production value	1.3	3.3	0.3	3.0	2.8	4.4	0.2	1.3
Number of employed	1.2	0.6	2.8	0.9	1.5	1.5	2.1	1.6
Specific costs of depreciation	1.2	1.2	3.5	1.8	0.8	1.1	1.7	0.7
Capital intensity of production	1.5	0.9	3.4	0.2	0.4	1.6	2.4	1.1
Labour productivity	2.5	2.5	3.1	2.1	4.3	2.9	1.9	2.8

Source: Calculated on the basis of *Annual Survey of Manufactures.* Cited in "Miroviye ceny: dolgovremenniye tendencii i noviye yavleniya", *Mirovaya Ekonomika i Mezhdunarodniye Otnosheniya*, No. 7, 1979, p. 114.

ties. The quantitative limits to imports from CMEA sources will make themselves felt more vigorously than before, the cost advantages of these imports relative to non-socialist imports and to the development of domestic mining will, in general, substantially diminish, and in certain cases even discontinue.[7]

The increasing difficulties of CMEA imports are basically connected with the specific development problems of Soviet mineral mining and with the inadequacies of CMEA cooperation.

The growth rate of several branches of the Soviet extractive industry will likely diminish during the period until 2000, which in turn will, in most cases, constrain the expansion rate of exports, too. For two opposite cases, the oil and natural gas, see Tables 9 and 10. The fall in the growth rate of Soviet raw material and energy export to CMEA countries is due to the following major factors:

- The shift to Trans-Ural regions of the centres of production of the basic sectors of the Soviet extractive industry will speed up in the period under review, with a steep rise in marginal production costs.[8] This will require such an immense need for development capital as the country, relying on own resources at a time of relatively moderate increase in national income, can hardly be expected to meet. Reliance on foreign loans may be substantial in relation to several developed market-economy countries, but in relation to the other CMEA countries, especially in a situation when the intra-CMEA terms of trade will presumably change in the future in favour of the Soviet Union and, consequently, a substantial need for consolidation credits will arise in the net resource importing countries, may hardly mitigate, to any appreciable extent, the accumulation burdens of the Soviet Union. As a result, the export-oriented expansion of Soviet mineral mining is likely to encounter the constraint of limited development capital in the period under review.
- In certain cases, e g petroleum, the expansion of exports is also limited by reserve availability problems.[9]
- The technological problems of mineral mining confronting more and more difficult geological and climatic conditions.
- Increasing bottlenecks in transporting raw materials and energy owing to the shift towards east of the geographical centre of extraction.

Table 9

A projected development of Soviet oil production, consumption and exports

(Mt)	1973	1980	1990[1]
Production	432	602	645
Consumption	328	443	513
Exports	117	160	132
Exports to Eastern Europe[2]	55 (47%)	70 (44%)	80 (61%)
Exports to Western Europe[2]	48 (41%)	66 (41%)	25 (19%)

Notes:

[1] Estimate of the Secretariat of Economic Commission for Europe.

[2] Figures in brackets represent share in total exports.

Source: *The Energy Economy of Europe and North America. Prospects for 1990,* Economic Bulletin for Europe, The Journal of the United Nations Economic Commission for Europe, June 1981, Oxford, Pergamon Press, p. 233.

Table 10

A projected development of Soviet natural gas production, consumption and exports

(EJ = 10^{18} joule)

	1973	1980	1990[1]
Production	8.3	15.3	26.4
Consumption	8.5	13.7	22.2
Exports	0.3	1.8	4.5
Exports to Eastern Europe[2]	0.2 (67%)	0.8 (44%)	1.6 (36%)
Exports to Western Europe[2]	0.1 (33%)	1.0 (56%)	2.9 (64%)

Notes:

[1] Estimate of the Secretariat of Economic Commission for Europe,

[2] Figures in brackets represent share in total exports.

Source: *The Energy Economy of Europe and North America, op. cit.* p. 167.

• The Soviet Union is, in most cases, likely to maintain in its resource exports the proportions established in the 1970s between the Eastern European CMEA countries and the developed market-economy countries, and over the long term will probably not expand its exports to CMEA countries to the detriment of its non-socialist exports. Parallel with the shifting towards eastern regions of the extractive and partly of the manufacturing industry, an upswing is expected in the "Eastern" trade of the Soviet Union, that is, a dynamic expansion of its raw material and energy exports to Japan, South-East Asia and possibly North America. This may influence the country's export capabilities vis-à-vis the European countries and even the internal supply in the European part of the country.

• In view of the falling growth rate of raw material and energy production, the trade-off between preferring exports and satisfying the relatively dynamically expanding domestic needs will probably be even more pronounced. In an economy with high specific raw material and energy consumption, the artificial reduction of, or the costly substitution for, domestic use in the interest of exports may involve serious growth-impeding effects. Hence, the country can, in the years ahead, probably give priority to exports only at the expense of domestic economic sacrifices greater than those experienced in the past. Therefore, export priority is likely to subside in areas where the above problems appear to be most pronounced.

• A deepening of integration in the extractive industry is unlikely to take place within the CMEA in the period under review to such an extent that it could make intra-CMEA resource flows significally more dynamic. The long-term raw material and energy target programme was drawn up in a one-sided demand approach, and it seems as if the financial resources for joint co-operation projects as envisaged in the programme are insufficient in the CMEA countries.[10] A massive reliance on non-CMEA financial resources would result in an inadmissibly large increase in indebtedness, and therefore this alternative may be excluded. In addition, the energy target programme is nuclear power-centric and did not envisage cooperation in the satisfaction of the demand for petroleum and natural gas.

Table 11

Tonnage and value forecast for 1990 for the imports of certain key mineral commodities by the European CMEA countries from the developing countries

Mineral	Quantity (Mt)		Price (USD/t)		Volume (MUSD)			
					Variant I		Variant II	
	Variant I	Variant II	current	1977	current	1977	current	1977
Petroleum	80-100	65-70	500	265	40000-50000	21200-26500	32500-35000	17200-18500
Natural gas[1]	30-40	25-30	–	–	–	–	–	–
Copper[2]	100[3]	80[3]	4740	2300	470	230	380	180
Bauxite	4-6	3.5-4	67.8	32.9	270-407	130-200	240-270	115-130
Iron ore	30-40	25-30	51.6	25.0	1540-2060	750-1000	1300-1540	625-750
Phosphate rock	15-20	15-20	78.5	38.0	1170-1570	520-700	1170-1570	520-700

Notes:

[1] $Gm^3 = 10^9\ m^3$ – [2] Metal content – [3] kt

Variant I = unsuccessful demand limitation policy

Variant II = successful demand limitation policy

Source: Own estimate. *Economic Relations between the European CMEA Countries and the Developing Countries and their Role in Development*, UNITAR Research Project Directed by József Bognár, Budapest, 1980, p. 91.

The possibilities and conditions of supplies from non-CMEA sources

From what has been discussed in the previous section one may draw the conclusion that the faster the increase in the supply costs of raw materials and energy imported from CMEA sources, *ceteris paribus,* the higher the relative profitability of imports from alternative sources. Several case studies concluded that the rise in the share of non-socialist countries, mainly developing countries, in meeting of East European import needs would become inevitable in the period until 2000. This applies to petroleum, natural gas, iron ore, phosphate rock and coal. For some commodities the projected 1990 import needs from non-CMEA sources are shown in Table 11.

As regards the conditions for long-term raw material and energy imports from non-CMEA sources, the following factors should be taken into account:

- In the mineral mining of developing countries there is a sharp competition by the Western transnational mining corporations commanding firm positions and substantial experiences in the key branches of the extractive industry in most developing countries.
- Political and economic risks, particularly in the case of large scale cooperation projects concluded for a long period, have to be considered as important calculation factors.
- The supply-security factor is assigned a more pronounced role.
- The developing countries will give priority to the export of semi-finished products as against the direct export of primary commodities, therefore it may appear, from the point of view of ensuring raw material supplies, to join in the establishment of appropriate manufacturing activities as a suitable form of cooperation.
- A raw material and energy import of a larger volume call for the establishment of an appropriate transport capacity.

Acknowledgement:

I am grateful to Bálint Balkay, Judit Gergely, Gábor Hunya, Károly Kiss, László Láng, István Pataki, Kálmán Pécsi, Magdolna Szöke and Adám Török who participated in the elaboration of the case studies.

Notes:

[1] Proven reserves are defined as that portion of mineral resources which can be economically and legally extracted at the time of evaluation. Below we refer to this category simply as reserves.

[2] Nine case studies, coal, petroleum, natural gas, atomic energy, uranium, iron ore and phosphate has been prepared within the framework of a research project of the Institute for World Economy of the Hungarian Academy of Sciences directed by the author.

[3] *Interfutures. Final Report. Facing the Future: Mastering the Probable and Managing the Undpredictable.* Paris, 1979, OECD, p. 47.

[4] Raymond F. Mikesell, *New Patterns of World Mineral Development,* Washington, 1979, British-North American Committee, pp. 89-92.

[5] Wolfgang Gluschke, Joseph Shaw, Bension Varon, *Copper: The Next Fifteen Years. A United Nations Study.* Dordrecht - Boston - London, 1979, D. Reidel Publishing Company, p. 64.

[6] *Ibid.,* p. 82.

[7] As a recent Soviet assessment has put it, "the improvement of the existing forms of cooperation, between the CMEA countries and the developing countries and the introduction of novel forms of relations can very well lead to a situation where, even under the changed price patterns of the world market, imports of fuels and minerals from the developing countries may prove not less efficient than imports from the Soviet Union". "Sotrudnichestvo razvivayushchimisya stranami v resheni i toplivno-sirevoy problemy stran SEV", in A. I. Zubkov, ed. *Toplivno-sirevaya problema v usloviyakh sotsialisticheskoy ekonomicheskoy integratsii,* Moskva, 1979, Izd. Nauka, p. 126.

[8] For example, in the case of fuels the share of Siberia in the total national output is expected to increase from 43 per cent in 1980 to 57–60 per cent by 1990 and 64–68 per cent soon after. (Ju.I. Maksimov, "Toplivno-eneryeticheskii kompleks Sibirii", *EKO,* No 10, 1982, p 105) Tony Scanlan refers to Soviet sources indicating the possibility of 20 fold increase in marginal costs in the use of oil. ("Outlook for Soviet Oil", *Science,* July 23, 1982).

[9] Especially with respect to petroleum this concern is also voiced by several Soviet experts. See, e.g., A.P. Krilov, "O tempakh razrabotk neftyanikh mestorozhdenii", *EKO,* No 1, 1980; N. Feytelman, "Mineralno-syrevayne baza SSSR i perspektivi yeyo ruzvitiya", *Voprosi Ekonomiki,* No 12, 1982.

[10] The increasing indebtedness of most small CMEA countries vis-a-vis the USSR, resulting from their consistently deteriorating terms-of-trade, since the mid 70s, heavily constrain their ability to participate in joint investment projects on the territory of the USSR, albeit the joint investment format was earlier considered to be the vehicle of further intra-CMEA extractive industry integration and the organizational underpinning of the long-term CMEA raw material and energy "target" program. As N. Inozemtsev, Deputy Chairman of Soviet Planning Office put it

> ". . . under such circumstances when, in the framework of trade turnover, most of the European CMEA countries have become indebted to the Soviet Union, the investment credits to the granted by these countries to the USSR lose their economic rationality."
> (Kursom ekonomicheskoy integratzii, *Planovoye Hozyaystvo,* No 8, 1981, p 19.) ■