ARE MINERALS COSTING MORE?

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PREFACE

This is a working paper in a continuing project "Mineral Scarcity and Economic Change", partially supported at IIASA by the U.S. National Academy of Sciences.

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In the present paper evidence is given on trends in relative cost to obtain minerals, for selected regions and countries. On this basis the question of increasing economic scarcity of minerals is addressed, and attention is given to the underlying forces that affect mineral cost trends.

The data that are used are from an IIASA data base that covers about 50 mineral price series and economic variables on 45 countries.

However, in this paper we focus primarily on Western European countries for the period 1950-1979. Since the data effort finished in summer 1980, the second oil price boom is not fully reflected.

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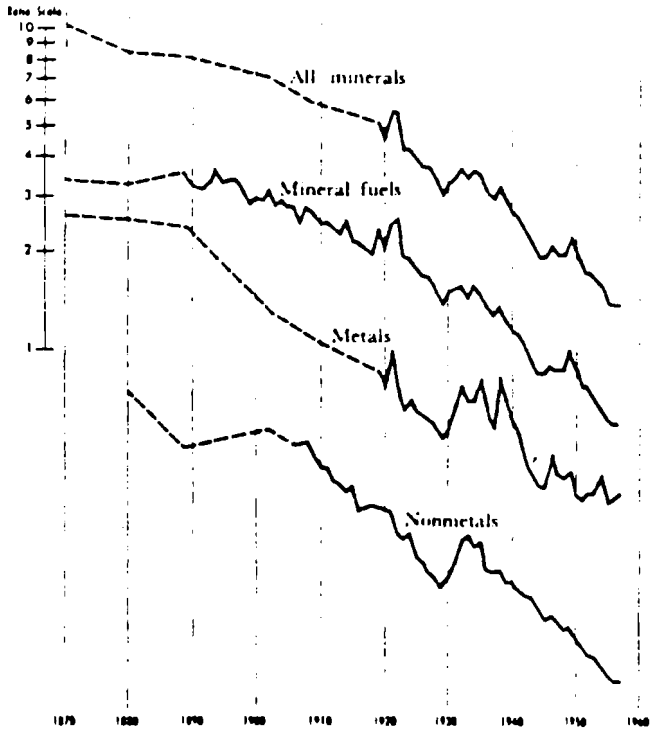
I. INTRODUCTION

There is widespread belief that minerals become increasingly scarce during economic growth. Two elements of the concept are: (i) the physical endowments of mineral resources are a fixed total, as compared to the increased demands from economic growth; and (ii) we tend to use the best economic resources first. Like agriculture, minerals are conceived to be a decreasing returns or increasing cost industry; formal economic literature for agriculture goes back to Smith, Malthus, Ricardo and Mill. In addition, the limited minerals resources are subject to depletion from use, and this is believed further to restrict returns. W.S. Jevons was one of the first to write on this, in 1863. A well known Hotelling theorem treats minerals as a capital asset subject to withdrawals. Most resources writings of the past hundred years, ranging from early literature on lebensraum and colonialism to the New International Economic Order, affirm the theory of increasing economic scarcity of minerals, related to physical limits.

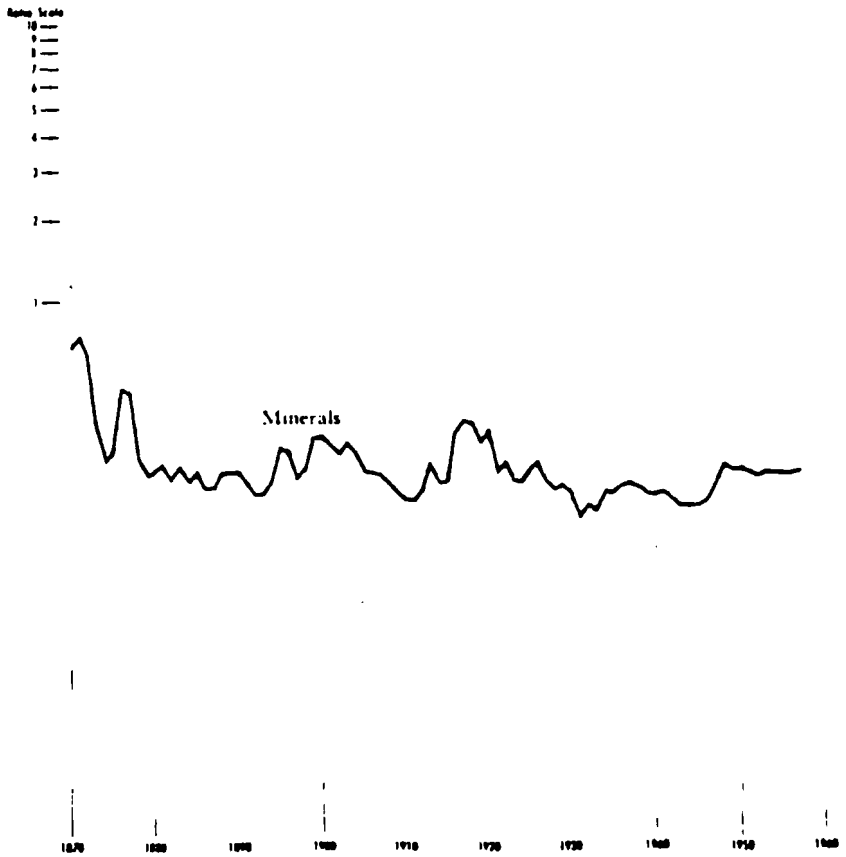
A number of writings, however, have questioned its relevance in the modern world, in concept and in fact. With respect to the diminishing returns theory, it is static. It thus omits consideration of increases in knowledge, improvements in techniques of production, transportation and use, discoveries of new resources and substitutes, growth in international trade, recycling, and other social-technical changes. With respect to the facts, a study from Resources for the Future discovered contrary evidence (Barnett & Morse, 1963). In the U.S.A., over a period of almost a century to 1957 minerals production was not subject to increasing costs, either absolutely or relative to non-extractive goods. Charts 1 and 2 summarize the data. In

CHART 1



U.S. MINERALS: Labor cost per unit of output 1870-1957. Note: solid lines connect points in annual series; dashed lines connect points over a year apart.

CHART 2



Trends in unit prices of mineral products relative to non extractive products in the U.S. 1870-1957.

Chart 1, we see that the opportunity cost of minerals in terms of mandays of labor to produce them has declined persistently. In Chart 2, we observe that opportunity cost of units of minerals in terms of other goods foregone did not increase. Another recent study marshalled evidence from geology and technology on potential mineral supplies and substitutions to cast doubt on the concept of ineluctable, pervasive, increasing economic scarcity (Goeller & Weinberg, 1978). However, public officals, the press, and book literature, as well as the general population, believe strongly in the doctrine of increasing economic scarcity of mineral resources, by a very large margin.

The matter is very important: the fact is that societies are making major decisions, with belief in increasing economic scarcity of minerals as explicit or implicit premises. This is true, for example, in energy decisions of nations, international negotiations over ocean resources, and Third World efforts to achieve a New International Economic Order.

The further simple fact, unfortunately, is that coherent evidence is lacking concerning the contemporaneous trend of costs of mineral resources in countries and regions. To a degree, societies are projecting future mineral costs without adequate understanding of their recent economic history. The present paper makes a step towards providing evidence. In this paper, we focus primarily on Europe and its countries. Our purpose is to give evidence on trends in economic scarcity of imported minerals, expressed as the relative costs for regions and countries to obtain them. For discussion of various economic scarcity measures, see Smith (1979) and Barnett & van Muiswinkel (1980).

Our basic measure will be the trends of world market prices. In all cases, unless otherwise explicitly stated, the mineral prices are deflated--that is, will be expressed relative to overall prices. For the European OECD countries as a group, our usual deflator is the price of GDP in OECD Europe (based on domestic currencies converted into dollars). When we turn to individual countries, the appropriate corrections for exchange rates will be made, and our usual deflator will be the country's wholesale price index or price of GDP. The effect will be that the corrected prices will not only express economic scarcity trends of minerals, but they will also take into account the economic situations of individual countries.

II. OECD - EUROPE

Overall Minerals Price Index

The UN has constructed an index of mineral prices overall. It includes the mineral fuels, ores, and crude fertilizers which are significantly involved in foreign trade*. The index

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* Crude petroleum, coal, natural gas, iron ore, manganese ore, chrome ore, phosphate rock--weighted according to trade values.

unadjusted for inflation increased 10-fold from 1950 to 1979. When deflated by the OECD price of GDP, the record is as follows:

Overall Mineral Prices (deflated)

1950	188
1960	134
1970	100
1974	308
1979	287

The annual increases from 1950 to 1979 average about 1.4% compounded. We see, however, that there was a declining trend from 1950 to 1970. Then in 1974, the minerals price index jumped sharply.

The evidence suggests the following observations:

(i) For this index it is not useful to generalize about a trend for the whole period, when the pattern has reversed and changed so greatly since 1970.

(ii) The increase since 1970 does not represent a "trend". It was an abrupt change in 1974, reflecting oil price increases.

(iii) It is probably misleading to generalize about prices of minerals, overall. Oil dominates the aggregate. In 1975, the oil statistical weight in the index was 85%, and in 1970 it was 61%.

For our purposes we abandon the overall index and turn to individual minerals and smaller groups.

Fuel Minerals Prices

The UN fuel minerals index (petroleum, coal, and natural gas) is weighted by international trade values, and thus is also dominated by petroleum. In 1975, petroleum was 90% of the index weight, and even in 1953 it was 70%. Again, it does not pay to look at the aggregate--it will move like petroleum, but a bit sluggish. We look at petroleum directly, then at coal.

Deflated oil prices declined from 1950 to 1970. They then increased moderately for a few years, as individual countries and OPEC negotiated higher prices or pressured oil companies for higher royalties. Prices then trebled in 1974, when the governments of the producing countries and OPEC took full control and have since moved sidewise. This is shown in the following data:

Prices of Petroleum (deflated)

	Major exporting countries	Saudia Arabia
1950	238	315
1960	159	173
1970	100	100
1971	116	117
1972	117	117
1973	133	139
1974	407	459
1975	342	424
1976	366	460
1977	366	449
1978	308	387
1979	379	441

The first column is a combined price of major oil exporters and the second is Saudi Arabia alone, each deflated by the OECD-Europe price of GDP. See also Chart 3. From these data and other knowledge the following conclusions can be formed.

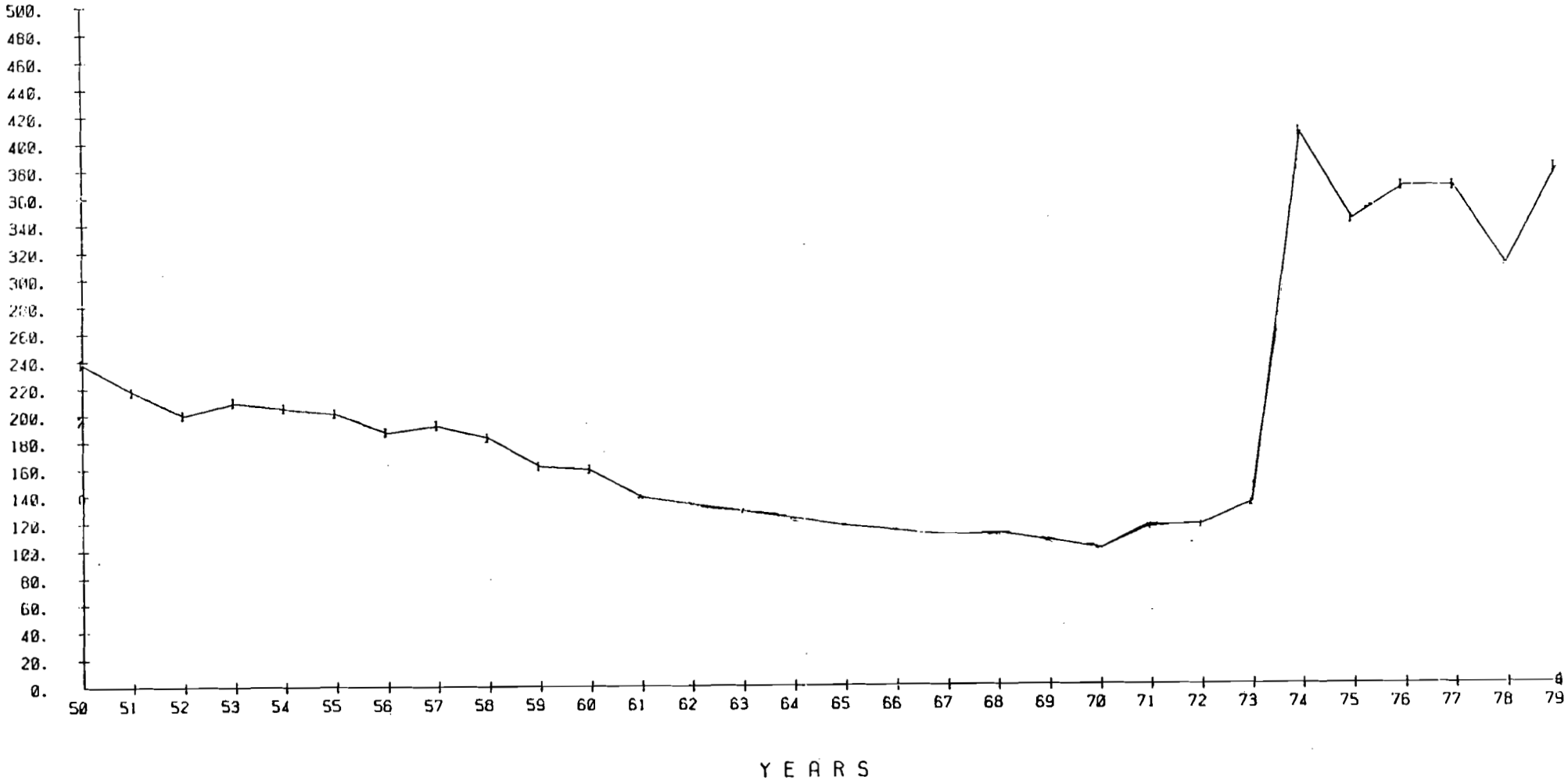
The first is this: the decline in relative price of petroleum 1950 to 1970 represented increasing *plenitude* of the natural resource, oil. Much of the incremental oil supply cost as little as 10 cents a barrel to find, develop, and produce. Even today such cost in the Middle East is less than $1. a barrel, as compared with a sale price of $30. The history of price statistics from 1950 to 1970 says that international oil supply from Middle East, Africa, Asia, and Latin America was becoming more plentiful and cheaper. This is why, of course, western nations rushed to invest in and develop and use it, in preference to their domestic sources and coal. The change in natural resource availability and technological conditions of supply under competitive conditions was toward increased plenitude--i.e. lower cost.

The second major conclusion has an opposite effect. Institutional parameters have changed. The increased economic and political cooperation of the major producers led to OPEC cartel controls which have been substituted for competition in supply. This is why relative prices rose in the 1970s, after an earlier period of plenitude. The OPEC claim that its price increases since 1974 have kept pace with inflation in industrialized countries is confirmed by the chart. The world economic scarcity of oil in the 1970s is mainly or perhaps exclusively due to institutional restrictions and levies on supply by the governments in oil producing countries--OPEC members and the non-OPEC price followers in all other countries, among them USA, USSR, Norway, Mexico, Egypt, etc. A qualification is that the industrialized countries as a group have tried to find and develop own petroleum resources, but have not been able to cover own needs.

CHART 3

OECD - EUROPE

PRICES OF IMPORTED PETROLEUM (DEFLATED)



Even if they could it might require higher prices than we have today. On a world scale without the current behavior of the main suppliers, however, it is likely that the pre-1970 trend would be closely followed, assuming ongoing efficiency improvements in finding and developing new resources.

We can draw a third conclusion if we look at the deflated prices of other fuels. Just as non-OPEC oil producers happily follow the higher prices in the cartel controlled international oil market, so also gas, coal, and nuclear suppliers have tried to follow oil prices upward in the 1970s. Their ability to follow is, of course, subject to their characteristics and limitations--natural resources, technology, institutions, and changes in these.

Deflated coal prices in international trade declined or were roughly constant from 1950 to near 1970, as demand shifted to cheap foreign oils. Later, in the early 1970s and especially in 1974, coal rose in price because oil became expensive and nuclear fuel supply was restricted. Since 1974, when relative oil prices have stabilized, coal prices have declined. The statistical record is as follows:

Coal prices (OECD-Europe GDP-deflator)

1950	141
1970	100
1974	162
1979	118

Is coal becoming increasingly scarce? Physically, coal reserves are very plentiful--hundreds and perhaps thousands of years of potential supply at present levels of use. Institutionally and technically, enlarged coal supplies are subject to enormous obstacles. These include safety regulations, pollution controls, transportation and manpower shortages, inadequate investment funds, and the threat of increased competition and capital loss from other energy suppliers. Whether coal supply becomes increasingly scarce and prices rise depends on the abilities of governments and industries to reduce these obstacles to coal production and use. Coal's present deflated price is close to the 1950 level.

We have only a few data on natural gas and no suitable data on nuclear. Natural gas prices tend to follow oil or sometimes coal, subject to the costs of gas transportation, the high value of imported LNG for peaking, and government regulations. A Dutch price series shows a 1979 index level of 130, relative to 1970. More generally, gas export prices, for example in Algerian efforts, have tended toward to btu price of oil. Nuclear fuel prices have been cartelized by producing governments and regulated by others, at levels much higher than in the 1960s.

Non-Fuel Minerals

We now consider major non-fuel minerals. These are the metallic minerals and crude fertilizers. (We ignore building materials--sand,gravel, cement, etc. These are ubiquitous, unlimited resources and are not major in international trade.) As before, the essence of the question is whether we can discover increasing economic scarcity in evidence of deflated price trends. We consider first the following aggregate minerals indexes, published by the UN, World Bank and UNCTAD organizations.

YA (minerals, ores, metals), comprised of iron ore, manganese ore, phosphate, aluminium,copper, lead, zinc, tin and tungsten.

MM (metals and minerals), comprised of the YA components plus nickel and bauxite (but we have this series only to 1978)

ANF (non-ferrous base metals), comprised of YA components plus nickel but excluding iron ore, manganese ore, tungsten and phosphate.

Has there been an increasing trend of deflated prices for non-fuel minerals groups from 1950 to 1979? The answer appears to be no. If the statistical data are valid, they are important evidence. They contradict wide-spread belief that these minerals, like oil, have been becoming increasingly scarce and expensive.

Has there perhaps been an increasing trend in these deflated price series in recent years, even if not since 1950? The answer again appears to be no. The deflated prices of non-fuel minerals groups may have even declined slightly in the 1970s. The data are as follows; (see also Chart 4):

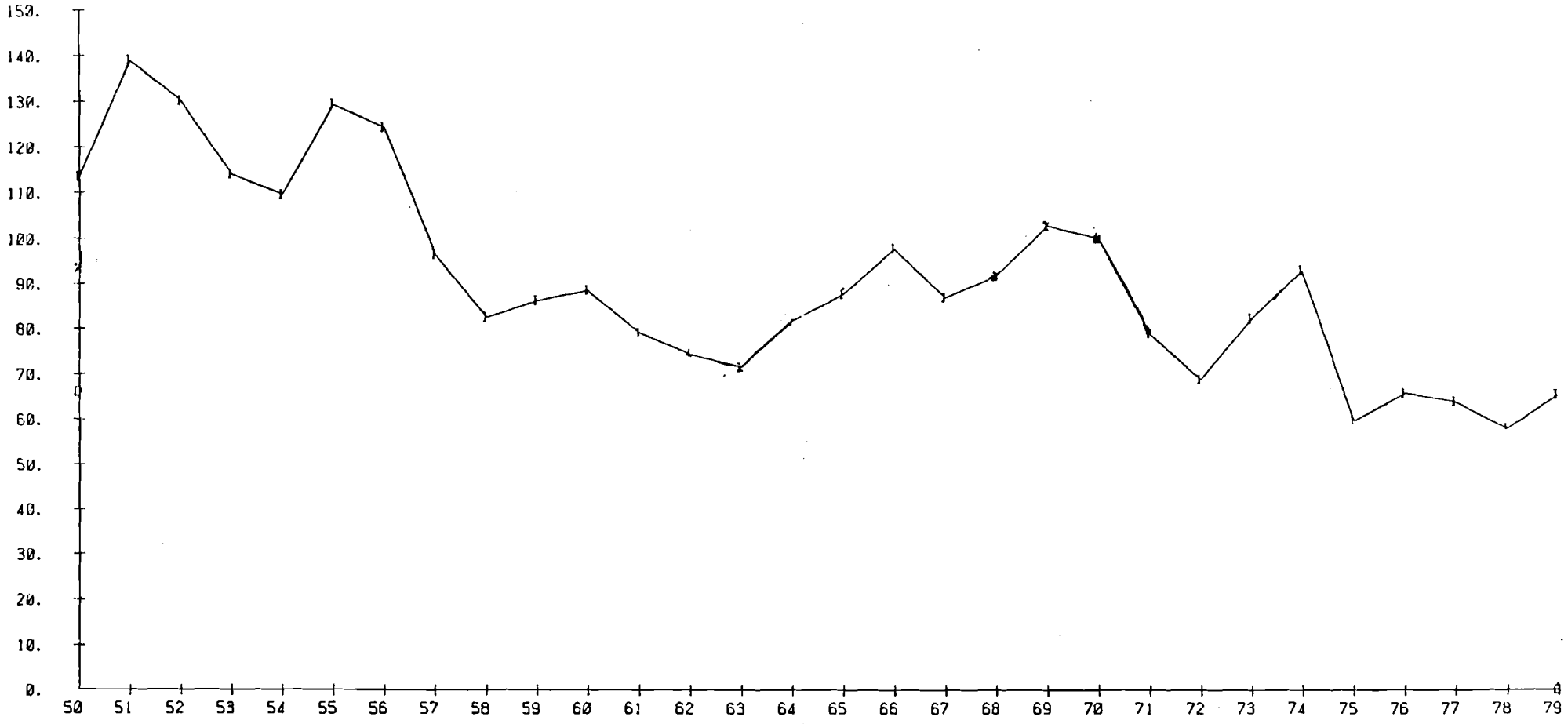
Non-Fuel Mineral Prices (OECD-Europe GDP deflator)

	YA	MM	ANF
1950	121	137	114
1960	96	106	89
1970	100	100	100
1971	81	79	79
1972	70	68	69
1973	85	82	82
1974	107	102	93
1975	76	75	60
1976	76	74	66
1977	73	69	64
1978	66	59	58
1979	72	-	65

CHART 4

OECD - EUROPE

DEFLATED PRICE OF NON-FERROUS BASE METALS (ANF)



There was a speculative mineral price boom in 1973-1974, but this was reversed by later decline and the more general inflationary burst of the 1970s. The boom as such was not exceptional, because the same has happened with these non-fuel minerals in 1951, 1955, 1966 and 1969, as the Chart shows.

Another explanation for the general concern might be that prices of many *renewable* raw materials showed a greater tendency to rise than the minerals. Deflated U.N. group indexes of prices of food and agricultural non-food commodities illustrate this: the 1974 values relative to 1970 were 144 and 135 respectively. (Like non-fuel minerals, relative prices then fell: 1979 values were 97 and 99.)

Individual Non-Fuel Minerals

We have more than a dozen individual minerals and metals on which to present evidence and must try to simplify. We start this way. All of them declined or were approximately level in deflated price from 1950 to 1979 (see Table A). In this respect, they give evidence against increasing economic scarcity of minerals. In some cases high peak values were reached, but these do not affect the general picture. Zinc and phosphate rock, for instance, reacted strongly in 1974, but prices declined rapidly during the years following.

The question which remains, is to detect whether there was a change in the trend in the 1970s towards increasing price. There are three such possible cases in the Table A data: lead, tin, and perhaps bauxite:

Prices (OECD-Europe GDP-deflator)

Table A

	1950	1960	1970	1974	1979
Copper	86	72	100	89	47
Nickel	81	87	100	83	79
Bauxite (Guyana)	-	-	100	103	117
(Jamaica)	149	93	100	118	113[b]
Aluminum	124	135	100	75	82
Lead	225	98	100	114	127
Zinc	250	123	100	224	86
Tin	132	88	100	133	139
Iron ore	145	157	100	83	58
Chrome ore	140[a]	128	100	78	105
Manganese ore	325	225	100	113	72
Manganese	555	239	100	126	85
Mercury	47	77	100	42	23
Tungsten ore	84[a]	41	100	69	73[b]
Phosphate rock	182	141	100	276	107
Potash	195[a]	135	100	117	81

[a] 1955

[b] 1978

Prices (OECD-Europe GDP deflator)

	Lead	Tin	Bauxite (Guyana)
1950	225	132	-
....	...	...	...
1969	101	99	106
1970	100	100	100
1971	78	87	107
1972	80	82	100
1973	91	86	95
1974	114	133	103
1975	70	95	127
1976	77	108	143
1977	95	138	149
1978	88	138	129
1979	127	139	117

It is difficult to view the lead changes from 1970 to 1979 as a scarcity trend. The annual figures are volatile, 7 of 9 observations are below 100, and the 1979 terminal figure is an abrupt 44% higher than the preceding year.

The tin figures, on the other hand, indicate a degree of scarcity: 5 of the 9 figures following 1970 exceed 100, and the drift of the 70s has been upward. Since 1956, the tin market has been influenced by the International Tin Council, by means of short-term buffer stock operations and export quotas, in an effort to influence and stabilize prices. Although ITC quotas were in operation during short periods in '73 and 1975-76, it is unlikely that this consumer-producer forum (the ITC per se) caused the upward trend in the 70s. This does not, however, exclude the possibility of institutional supply restrictions by individual producers and countries.

The bauxite trend in the 1970s, although weaker, also perhaps indicates scarcity. However, it is purely an institutional phenomenon. Bauxite and substitutes are extraordinarily plentiful resources. The individual producing countries have negotiated improved terms with the few oligopoly buyers. Improvements were overdue, but the methods of change were unfortunate in Jamaica and possibly elsewhere. The International Bauxite Association, however, is little effective as a cartel; it is unable to control quantities or prices (Barnett, 1979).

With these two possible exceptions, all the evidence of the 15 individual non-fuel minerals and metals series and 3 group series testify against increasing scarcity: the significant ores, metals, and fertilizers have not had a rising price trend relative to the price of all goods and services in the OECD-Europe aggregation of nations.

III IMPACTS ON INDIVIDUAL COUNTRIES

The foregoing analysis has treated the mineral scarcity hypothesis--the supply price conditions for the Western European economy as a whole.

We now consider what these have meant for the individual countries. To do this in full degree is beyond our capability. It would require that we compare the changes in the prices of mineral inputs with changes in the prices of other production inputs; then observe shifts in minerals use and factor proportions induced from changes in prices and technology; and then appraise a variety of macro and parameter change effects, leading to effects on income and output per capita.

At this time we can only do the first of these. We compare changes in prices of imported minerals with changes in wholesale prices (or prices of GDP) in individual countries. Since international mineral prices (P_i) are expressed in dollars and wholesale prices (WHP) in domestic currency, we make them comparable by employing a foreign exchange conversion factor (FE). This is the number of units of domestic currency per dollar, in each year. Thus we can compare: ($P_i \times FE$) with WHP. Alternatively, we can express the relationship as P_i vs. FE/WHP, and we can look at the real cost of minerals in terms of domestic wholesale goods generally by observing $P_i \times FE/WHP$.

Petroleum

Almost all countries benefitted from discovery and development of the remarkably cheap oil of Middle East, Africa, and other places during the two decades, 1950 to 1970. During the world wide, gradual inflation of the period, petroleum prices in the consumers' own currency generally increased slower than wage rates or wholesale prices. Cheaper petroleum was substituted for other fuels and other factors of production with attendant increases of productivity of labor, capital, and other inputs.

In the decade of the seventies, the process reversed. Every country without exception experienced increase in imported petroleum cost, in own currency. The increases far outran increases in costs of other factors. Efforts have been made to substitute labor, capital, and other inputs for expensive petroleum, with inevitable losses in productivity.

The strength of the petroleum price movements in both periods was large. It was so dominant that the pattern of impact was common for all nations--significant decline in relative price in 1950-1970, enormous increase in 1970-79.

Yet, eyen so, the variability of effect on consuming nations was substantial. Table B arrays the relative impacts of petroleum price changes compared with wholesale price changes from 1950 to 1979 upon most of the OECD European countries.

TABLE B. Relative prices of imported petroleum

	Ratio: $\frac{P_{pet} \times FE/WHP}{(1970=100)}$			
	1950	1970	1974	1979
Austria	159	100	376	373
Belgium	133	100	383	420
Denmark	154	100	357	368
Finland	132	100	361	401
France	136	100	365	432
FRG	160	100	364	367
Greece	115	100	375	418
Ireland	173	100	440	399
Italy	137	100	391	431
Netherlands	146*	100	389	386
Norway	191	100	377	409
Portugal	143	100	377	417
Spain	168	100	374	383
Sweden	161	100	383	409
Switzerland	127	100	334	323
UK	158	100	452	401

*1953.

In Europe the largest and least relative impacts from the OPEC price rise from 1970 to 1979 were as follows:

Ratio: $\frac{P_{pet} \times FE/WHP}{1970=100}$

Largest		Least	
France	432	Switzerland	323
Italy	431	FR Germany	367
Belgium	420	Denmark	368
Greece	418	Austria	373

We learn the following. When the actual mineral price change is very large (the petroleum dollar price rose 11-fold), the impact is clearly visible in the relative factor prices in each of the nations. But the impact is felt differently among nations for a variety of reasons. Among them is relative strength of own economy as manifest in foreign exchange and domestic prices. Another main element in effect of the oil price rise is whether the country is an oil producer and thus somewhat shielded, or even is a net exporter.

Non-Fuel Minerals

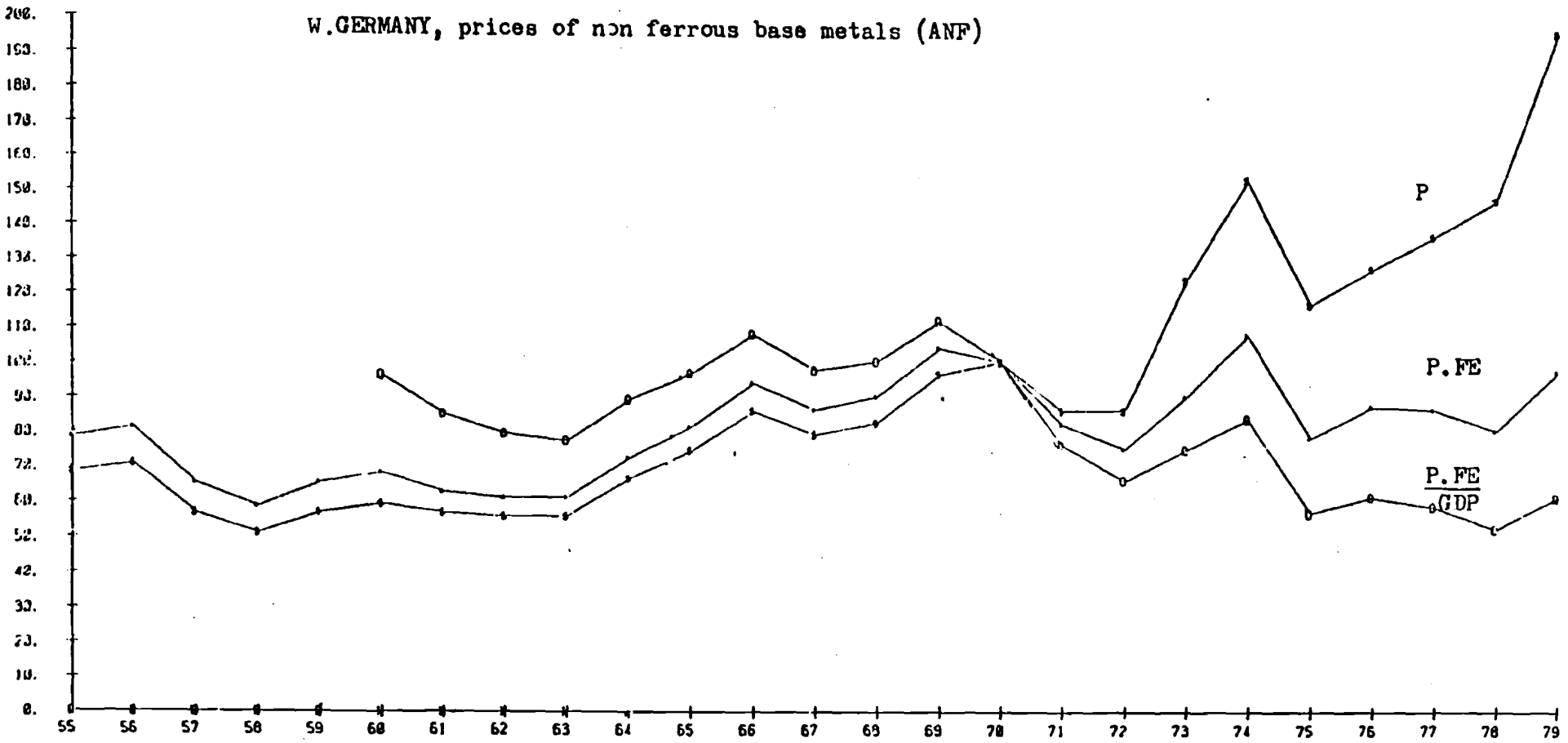
In the case of non-fuel minerals, international mineral price increases expressed in dollars were far smaller than in petroleum. The differences among countries in the multiplicative deflator index (FE/WHP) then played a more substantial role in the calculations of deflated mineral prices than for petroleum.

How shall we present the information on relative price movements of individual minerals to the individual European consuming nations? We start with a figure for Germany (FR). It shows the trend of the nominal world market prices of non-fuel minerals--then these prices adjusted by the rising value of the Deutsche Mark relative to the dollar; and then this price further adjusted by the price of GDP in Germany (FR). The result is the price of the imported minerals relative to the price of all other economic goods in Germany, both expressed in DM and converted to index numbers.

However, with 16 nations and price indexes for more than 15 non-fuel minerals, the story would become repetitive and tedious. We try to avoid this by summarizing and simplifying in three ways. First, we remind the reader of the evidence presented earlier for the OECD group of nations as a whole: in only tin and perhaps bauxite among the non-fuel minerals, for only the 1970-79 sub-period, did we find what may be significant increases in relative prices (see pp.11). Second, we shall ignore declines or constancies or small increases in relative prices which characterize most of the minerals. We shall focus only on cases of possibly significant trends of price increase. We define these as increases which average 2% or more a year, compounded, for relevant periods. (For orientation: an average annual rate of 2%, compounded, doubles relative price in 35 years. Commodity prices fluctuate widely in short periods, sometimes 10 to 50% in a year or two.)

Third, we observe two patterns which typify the impacts of international mineral prices upon the price and foreign exchange systems of European countries. One group of countries is represented in this respect by (say) Austria. The other pattern is represented by (say) Belgium. The patterns are defined by the countries' multiplicative deflators (FE/WHP), which are applied to the common dollar international mineral prices. Table C presents these countries and information on the trends of their multiplicative deflators.

CHART 5



P in $

P.FE in D.M.

P.FE / GDP deflator

TABLE C. Average Annual Compound Rates of Decline in FE/WHP (percent)

	1950 to 1979	1970 to 1979
Group 1		
Norway	5.5 percent	10.7 percent
Ireland	5.4	10.9
Spain	5.4	11.3
FR Germany	5.4	11.8
Austria	5.3	11.6
Denmark	5.3	11.7
Netherlands	5.2	11.2
United Kingdom	5.0	10.9
Switzerland	5.0	13.0
Group 2		
Finland	4.6	10.9
Portugal	4.6	10.4
Belgium	4.3	10.2
Italy	4.3	10.4
France	4.3	10.2
Greece	3.8	10.4

For the first group of countries, we find possibly increasing relative price trends for 2 non-fuel mineral commodities. These occur in the period 1970 to 1979 only. These commodities are tin (relative price rises about 3.5% a year) and lead (about 2.5%). This finding identifies as possibly scarce the same minerals as earlier for OECD-Europe as a group, where the deflator was the price of GDP except for bauxite (about 1.8%). The comments made there are applicable here as well--the period is short, only a decade; the annual lead changes are erratic; and revealed scarcity of tin is probably attributable to institutional influences rather than to natural resource limitations or technological conditions.

For the second group of OECD countries we find (in addition to tin and lead) the following candidates for scarcity trends:

	France, Italy Relative price increase per year (percent)	
Mineral	1950-79	1970-79
Tin	2.6%	5.2%
Lead	0.4	4.2
Bauxite	1.6	3.4
Nickel	2.4	-1.1
Chrome ore	1.7	2.0
Tungsten ore	2.6	-2.0
Phosphates	0.5	2.2

To a degree, these scarcity effects--increase in relative prices of minerals in this group of countries--represent the individual country developments in trade and domestic economic affairs. This is why bauxite, nickel, chrome, tungsten, and phosphates appear here, and not in the first group of countries as well, and why the rates of increase in the prices of tin and lead, are higher.

Second, concerning the additional minerals, there are unanswered questions:

- Nickel and tungsten: what accounts for the change in direction of movement only since 1970? It is not consistent with the idea of a persistent, long-term scarcity trend.

- Phosphates: we have an alternative price series, also for Morocco phosphates, which shows decline in relative price 1950 to 1979, and increase of only 1 1/2% a year in 1970-79.

- Chrome: the increasing price in each period and its acceleration in 1970-79 tend to support the increasing scarcity hypothesis, in mild degree.

Finally, we conclude as follows, concerning non-fuel minerals. There is very little support for Malthusian, Ricardian, or Hotelling hypotheses of increasing mineral scarcity. Most of the individual minerals and also the non-fuel minerals group indexes have declined or been constant in relative price. The few instances of evidence of scarcity in supply can be more readily related to the institutional phenomena of governmental interventions than to natural resource deposits or technological conditions. In addition, in a number of Western European economies, several international minerals are costing more in terms of foreign exchange and domestic goods. This is an increase in unit value of imported mineral because of deflator change. It is due to decline in the international value of domestic goods, and is not related to technology, costs or institutional conditions of foreign mineral supply.

IV PRICE IMPACTS ON DEVELOPING COUNTRIES

It is apparent that changes in international mineral supply prices have varied impacts upon the price and cost systems of the consuming countries. We just analyzed and discussed this with respect to Western European countries. We now want to observe the differential impact of changes in international oil and coal prices in the 1970s upon developing countries. We want to compare them with changes in prices of other factors. As before, we do this by examining deflated mineral prices, $P_i \times FE/WHP$. For orientation, we also show the impacts on Austria and Belgium. The data appear in Table D.

TABLE D. Deflated Prices of Oil and Coal ($P_i \times FE/WHP$) in 1979

	(1970=100)	
	Petroleum	Coal
Egypt	938	292
Pakistan	780	242
India	589	183
Zambia	566	176
Brazil	553	172
Thailand	481	149
Korea	455	141
Malaysia (GDP deflator)	440	137
Colombia	387	120
Phillipines	359	112
Argentina	328	102
• • • •	•••	•••
Austria	373	116
Belgium	425	131

We learn the following. In general, the impact of the petroleum price rises of the 1970s was substantially greater in a sample of developing countries than in developed Western European nations. The cost of energy relative to domestic goods and foreign exchange went up more sharply in LDC's. The price pressure to substitute away from the imported energy commodities and the tendency for factor productivity to fall was stronger. One unhappy choice was to reduce even more greatly energy inputs in productive activity, thereby reducing productivity of labor and other factors and growth of GNP. The other was to maintain such energy use and pay for it by exporting more at lower prices, thereby reducing growth of real GDP, or by borrowing more foreign exchange.

Beyond these adversities were dislocations and disruptions. Even in advanced economies like the U.S. and Europe, with developed, more efficient market and public decision institutions, the economic losses merely from adjusting to the sharp price changes were large. Developing countries are far less robust in economic efficiency

mechanisms. Energy supply catastrophes in these countries have been averted only by extreme extensions of credit from the developed countries. These are unlikely to be repaid or properly serviced, and risk wide-spread financial catastrophes.

The evidence here, which includes domestic price trends, supports the observation that developing countries which do not export oil have experienced greater balance of payments problems from OPEC prices than developed nations.

V SUMMARY AND QUALIFICATIONS

Since World War II, natural resource and technological change conditions for all minerals have tended to result in improved supply, and thus declining or constant prices, relative to the overall price level in OECD-Europe. However, in the last decade the development of institutional innovations has restricted the supply of oil. The powerful OPEC cartel has engendered scarcity and substantially increased prices of petroleum. This has tended to increase prices of other fuel minerals. Also, in this decade, but in lesser degree, governments have fostered stabilization or moderate increases in tin and bauxite prices. Thus, in the decade of the 1970s, OECD-Europe has experienced increasing economic scarcity of fuels and of two other minerals of the group considered.

The scarcities have institutional causes. European industrialized countries depend substantially on minerals supply from developing countries, and have invested and produced in them under favourable conditions in the past. This situation, however, has been changing in recent years. Developing countries have been increasing control over the exploitation and exports of their natural resources. In some cases this results in higher prices and thereby increased economic scarcity of the minerals.

The impacts of mineral price changes on individual countries differ substantially. Different trends in exchange rates and domestic price levels caused relative prices of some imported minerals to indicate increasing economic scarcity in certain countries, where increasing plenitude was registered in other countries. Especially the developing countries are confronted with severe impacts from rising energy prices.

These findings rest upon the validity of the price indexes of the commodities and of the OECD-Europe price indexes. The sources are respectable--UN, World Bank, OECD, London Metal Exchange, etc. In addition we have compiled data on more than one index for most of the individual commodities and groups, and they give roughly the same results as those we reported, above. It is also useful to observe that the statistical trend results are similar in both group and individual commodity data. But we are at an early stage of a long-term study, and it would be desirable to identify still other worthy indexes and see whether these give the same results.

Explicit consideration should also be given to several major influences on minerals prices and deflators in the 1970s. Increases in oil prices have directly pushed up costs and prices of minerals, transportation, and other goods generally. Also, increased governmental interventions on social legislation, environmental pollution, safety, and energy conservation have reduced productivity advances and increased prices. On the other hand, reduced economic growth rates have tended to depress demand for and prices of minerals in the world economy. These several influences have obviously influenced both numerators and denominators of our measures of relative prices.

APPENDIX NOTES

Appendix A: Prices of Imported Petroleum relative to prices of labour.

A strong form of the classical concept of increasing natural resources scarcity is that their prices will rise relative to prices (wage rate) of labour during economic growth. Contemporary economic growth theory holds, contrariwise, that labour is the factor which becomes increasingly scarce and because of productivity advance, its price will rise relative to natural resources. It is useful to look at the evidence on relative scarcity of labour and petroleum during the 1970s, following OPEC's entrance into control of oil markets. We look at the ratios of imported petroleum prices per barrel to the wage rates in the consuming countries, adjusted for foreign exchange ratios: $P_{pet} \times FE/WR$.

Table E shows that imported petroleum has become very scarce relative to labor in European countries since 1970. In 1979, increase in petroleum price was about 2.3 to 4.2 times the increase in wage rate in the countries in OECD-Europe.

We may suggest the significance of these large relative price increases of petroleum. In these western market economies, factor proportions and relative marginal productivities of factors tend to be adjusted to the ratios of their prices. Such large price ratio changes of oil relative to labor would call for substantial efforts to change factor proportions. So doing would significantly affect factor productivities and in particular would slow productivity advances of labor. In fact, advances of labor productivity have slowed greatly in the 1970s, and some part of this is the effect of the great rise in petroleum prices.

TABLE E. Relative prices of imported petroleum

P_{PET} x FE/Wage Rate*

(1970 = 100)

	1970	1974	1979
Austria	100	290	233
Belgium	100	274	227
Denmark	100	303	-
Finland	100	318	302
France	100	321	251
FRG	100	314	272
Greece	100	380	276
Ireland	100	349	-
Italy	100	363	290
Netherlands	100	295	255
Norway	100	326	291
Portugal	100	235	-
Spain	100	278	-
Sweden	100	381	419
Switzerland	100	309	242
UK	100	405	340

P_{PE} x FE/Wage Rate in 1979

1970 = 100

Largest			Least
Sweden	419	Belgium	227
UK	340	Austria	233
Finland	302	Switzerland	242
Norway	291	France	251

* Wage rates refer in most cases to hourly earnings.

Appendix B: Sources of data

a) Commodity price indexes

Description	Source
- Minerals overall: Fuels (94%, Petr.,Coal, Gas), Iron ore (3.5%), Manganese ore (0.3%), Chrome ore (0.2%), Crude Fertilizers (1.5%)	UN
- Petroleum, major exporters: Saudi Arabia f.o.b. Ras-Taruna (37%), Iran f.o.b. Kharg Island (19%), Iraq f.o.b. Khar al Amaya (10%), and others	UN
- Petroleum Saudi Arabia: Ras Taruna	IFS
- Coal: U.S.A. coking coal c.i.f. North Sea (66%), Germany FR, hard coal ex-mine (34%)	UN
- Minerals, ores, metals (YA): Phosphate rock (11%), Manganese ore (2%), Iron ore (21%), Aluminium (13%) Copper (33%), Lead (2%), Zinc (4%), Tin (12%), Tungsten (1%)	UNCTAD
- Metals and Minerals (MM): Copper (LME), Tin (LME), Nickel (Can), Aluminum (NY), Lead (LME), Zinc (LME), Iron ore (Braz.), Bauxite (U.S. Jam.), Manganese ore (India); weighted by 1974-76 developing countries export values	WB
- Non ferrous base metals (ANF) : Copper (44%), Nickel (10%), Aluminium (28%), Lead (4%), Zinc (8%), Tin (7%)	UN
- Copper: U.S.A. f.o.b. atlantic (9%), LME wirebar (91%)	UN
- Nickel: Canada producer price f.o.b.	UN
- Bauxite: U.S. Imports Jamaica U.S. Imports Guyana	WB IFS
- Aluminium U.S.A. producer (18%) Canada del. U.K. (82%)	UN
- Lead: U.K. LME (86%) Canada (14%)	UN
- Zinc: U.K. LME (73%), Canada (27%)	UN
- Tin: Malaysia, ex works Penang (73%) U.K. LME (27%)	UN

- Iron ore: Brazil (45%), Canada (25%) Sweden (18%), Liberia (11%)	UN
- Chrome ore: Turkey, ci.f. euroports	UN
- Manganese ore: India, ci.f. euroports	UN
- Manganese: India, U.S. ports	IFS
- Mercury: Spain	EMJ
- Tungsten: c.i.f. Europe	UNCTAD
- Phosphate rock: f.a.s. Casablanca	UN
- Potash: Canada	IFS

The prices on price indexes are from five different sources. All series have been transferred into indexes with 1970=100 and are based on U.S. dollar prices. They can be found in:

- "Methods used in compiling the U.N. indexes for basic commodities in international trade", U.N. Statistical Papers, Series M,No.29, Rev.2 of 1979. These series have been updated with the "U.N. Monthly Bulletin of Statistics" of July 1980. Weighting patterns are adjusted every five years (latest 1975) and are based on trade patterns.
- "International Financial Statistics" of the IMF, Yearbook 1979 and August 1980 issue
- "Commodity Price Forecasts", World Bank, May 1979.
- "Monthly Commodity Price Bulletin", Special Supplement and Handbook, UNCTAD, Geneva.
- "Engineering and Mining Journal", March 1980.

b) Exchange rates

Used were "International Financial Statistics" (IMF) quotations of the period averages (yearly) of par rate/market rates (line rf). For countries that express dollars in local currency reciprocals were taken. All exchange rates were converted into index numbers with 1970=100.

c) Wage rates

Sources are the ILO Yearbooks 1975 and 1979, and the most recent ILO Quarterly Bulletins and Supplements. The wages are for manufacturing (all industries), either expressed as earnings or rates per month, week, hour or day. The data are annual averages except for some of the 1979 values, where the latest monthly data were taken. All wage rates were converted into indexes with 1970=100.

Wholesale Price Indexes

Sources are IFS volumes, country pages, line 63. They differ in coverage which might complicate country comparisons. The series have been re-based on 1970=100.

Implicit GDP-deflators

These deflators are from the UN Yearbook of National Account Statistics 1977, table 8A. For the years 1976-1979 the deflators are based on IFS series, by dividing GDP (line 99b) by GDP in 1975 prices (line 99 bp). These series were rebased to 1970=100 and linked to the U.N. data. The OECD-Europe GDP deflator was computed from OECD "Main Economic Indicators".

Growth rates

The growth rates are compound interest rates, or the i from $X_x = X_0(1+i)^n$, where X_n and X_0 are the latest and first value for the period)...n.

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