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THE ROLE OF INDUSTRIAL MINERALS IN THE ECONOMIC GROWTH OF THE DEVELOPING COUNTRIES

by

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ABSTRACT

Traditionally, the main role of mining in developing countries (DCs) has been the provision of foreign exchange. The assimilation of mining to its metal and energy components whose outputs are largely exported has contributed to the accreditation of this mining image. Most of the industrial minerals are abundant and are low value per weight unit commodities. Therefore they are not traded in international markets and do not generate foreign exchange.

For this reason, there is now a current of opinion that the industrial minerals have been neglected by the DCs because of the lure of the higher value commodities. The aim of this study is to test this opinion and, if correct, to suggest remedial measures.

Because industrial minerals are such a diverse group of commodities, this study first screens them in order to determine those which could be potentially neglected in the DCs. They are identified as the raw materials for the glass, ceramics, and construction industries. Because of the lack of industrial base, most of the glass and ceramic products are ultimately used in the construction sector. The construction sector

is then the major industrial minerals market in the DCs.

International trade data show that DCs rely more on imports of industrial mineral products than do the developed countries. More specifically, the data show that construction materials represent more than half of the industrial mineral products imports value for the DCs compared to only about 18 percent for the developed countries. However DCs self-sufficiency in industrial minerals has been increasing over time. There is not enough evidence to show that the industrial minerals sector is neglected in the DCs, but there is a need for a policy to ensure that the self-sufficiency is achieved in an optimal way. In this respect, a balance must kept between different sizes of production plants in order to match the geographical distribution of demand. Lastly, measures are recommended to DCs to boost the development of this sector.

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CHAPTER 1

INTRODUCTION

Historically, the role played by mineral resources in world development can hardly be overemphasized. There is, however, an uneven recognition of the importance of the respective components of the mineral sector. Often, one reads in the literature that the Western industrial revolution was made possible by the availability of iron and coal. The fluxes used with iron ore and coal in steel production, and the construction materials used in building the foundries are seldom mentioned. This illustrates how industrial minerals are generally overshadowed by metallic and energy minerals.

There seem to be two main reasons for this situation. First, industrial minerals are considered abundant, and it is taken for granted that wherever they are in demand, there will be enough supply at a reasonable distance to meet it. Second, most of the industrial minerals have a low value per unit of weight. This means that little of it enters international markets. Therefore the vast literature on international trade is foreclosed to most of these commodities.

Data on industrial minerals at the international level are not readily available except for those commodities which enter the international trade. In developed countries, either the national bureau of mines or the government body in charge of mines keeps accurate accounts of industrial minerals production. In developing countries (DCs) however, because of the existence of a large nonmonetary sector whose consumption is not reported, official production figures are much lower than real production. This is especially true for most of the materials used in the self-help or informal building sector.

This study focuses on the role of industrial minerals in the DCs. Most minerals, whether metals or nonmetals, are used as raw material for industrial production. In most of the DCs, metal fabricating industries seldom exist, and metal production is generally exported. For this reason, the role of metal mining and, by extension, of mining in general has been to provide foreign exchange. Metal mining direct linkages with the rest of the economy are rather minimal since metal mining tends to be capital intensive and its output is not used by the national economy. On the other hand, industrial minerals are generally used by

local, regional, or national industries and therefore are more integrated in the domestic economy.

The industrial minerals are a large group of commodities whose definitive common characteristic is that they cannot be categorized in either the metals group or the energy minerals group. Some of them, e.g., diamonds, are mined essentially for the export market and the subsequent generation of foreign exchange. Other commodities have such a high place value that their mining regulations should be left to the local authorities. There is a group of industrial minerals, however, which, when processed, can be traded internationally because the processed products are essential to the economy. These products are vital to the construction sector, their major end use; if not produced domestically, they must be imported. The raw materials for these products are generally available in virtually any country. These products include construction materials such as cement, glass and ceramics. Because of the importance of construction to the economy, significant dependence on imports for these products is undesirable. In fact, DCs have been successful in increasing their self-sufficiency in regard to these materials. This can be illustrated by

the present shift in the geographical distribution of cement production; most of the growth in world cement production is taking place in the DCs; production in developed countries is almost stagnant.

The self-sufficiency advocated here does not evolve from any nationalistic view but rather is a logical consequence of the need for foreign exchange savings. Even more important, it reflects the need to minimize the transportation distances of vital commodities characterized by a low value per unit of weight. It is further suggested that whenever feasible, national, regional, and even local self-sufficiency should be sought. Practically, this could be achieved by a balance of large-scale and small-scale production plants optimally dispersed throughout the country according to the geographical distribution of demand. Additional benefits of small-scale plants are discussed. Administrative and fiscal measures are suggested to DCs governments to boost production and to optimize the distribution of construction materials of industrial mineral origin. Further research within the group of construction materials and the broader field of industrial minerals is suggested.

Because of the diversity of the industrial mineral

field, the creation of an institution responsible for the development of the overall industrial mineral field is not recommended. This author believes that specialized institutions dealing with homogeneous groups of minerals will be more effective in fostering their development than will an overall industrial mineral institution. For instance, a fertilizer institute attached to the ministry of agriculture could bring more development to fertilizer raw materials than an industrial mineral institution. This is in contrast with other opinions which consider the lack of a unique overall supervision of the industrial minerals as an impediment to the development of this sector. The specialized institutions, however, should maintain a necessary link with the national geological survey in order to identify the sources of the raw materials.

CHAPTER 2

THE PROCESS OF ECONOMIC GROWTH IN DEVELOPING COUNTRIES

Narrowly defined, the objective of the DC policymaker is to implement measures which will lead to a rapid increase in the gross national product (GNP). But to effect real economic growth, the focus must be on raising per capita GNP rather than the absolute GNP.

A rise in population growth could offset any gains achieved by a rise in the absolute GNP. This would result in a decrease in per capita GNP and a impoverishment of the society.

Emphasis has long been placed on economic growth even though it is only one component of the overall development process. Per capita GNP has been widely used as a development indicator without considering how the gains are distributed. Identifying the recipients of national income is now accepted as economically relevant. Who receives the income determines what goods the incremental income will be spent on and what the growing sectors of the economy will be.

Since on equity grounds, expenditures on basic needs are preferred, there may be a trade off between income growth and income distribution from the point of view of the DC policymaker. In this work, however, it

will be assumed that the objective of income growth will have priority over income distribution, and that whenever there is a conflict between the two, it will be resolved in favor of growth. Also, GNP indicators will be expressed in real GNP terms, not in nominal terms.

For convenience, this study will depart from the tradition of breaking down GNP in the categories of consumption, investment, goverment spending and net exports. The GNP will be defined as follows:

$$GNP = D_T + D_M + E_X - I_M \qquad (1)$$

where D_T is the contribution of the subsistence subsector of the agriculture sector towards the GNP,

D_M is the part of the contribution of the modern domestic sector towards the GNP which is consumed within the domestic economy,

E_X is the aggregate gross export contribution towards the GNP, and

I_M is the aggregate expenditure on imports.

The four terms in expression (1) suggest four ways of increasing the GNP: increasing D_T, D_M, or E_X, or decreasing I_M. However D_M, E_X, and I_M may be lumped together and referred to as the modern sector

contribution to the GNP. With this simplification, one can distinguish between a modern or an industrial, and a subsistence or nonindustrial sector. Although the best economic growth strategy will be one which does not introduce bias in either of the sectors, one can talk of two alternative ways of achieving economic growth: the promotion of agriculture and industrialization.

2.1 Promotion of Industry as an Approach to Economic Growth

The early development economists equated economic growth with industrialization. This line of thinking was based on the following empirical and historical evidence.

-Labor productivity in industry is generally higher than in agriculture;therefore, transfering labor from agriculture to industry increases the GNP.

-In the industrialized countries the share of agriculture in the GNP is much lower than in the developing countries.

Various strategies have been devised, and, depending on where the emphasis is placed, the literature distinguishes four different industrialization strategies:

a) Import substitution

b) Exports promotion

c) Basic goods production

d) Further processing of raw materials for export

Because more than one criterion has been used to derive them, the four strategies can be reduced usefully to two--import substitution and export promotion. Increasing the degree of export raw materials processing could be included in exports promotion.

The industries classified in the basic goods strategy overlap both the import substitution and the exports promotion strategies.

> The type of industry that falls into this category includes not only capital-intensive and heavy industries such as iron and steel, cement, fertilizers, but also such light and labor intensive industries as textile mills and fruits canning for which the countries have the necessary raw materials (Oduolowu 1977).

Because DC economies were once agrarian, consumption of the products of those industries were imported. There is no reason why they could not be produced domestically and exported. Therefore only import substitution and export promotion will be considered as distinct industrialization strategies.

2.1.1 Import Substitution Industrialization Strategy

"By definition and intent, import substitution is a

systematic attempt to replace costly imported goods with locally produced substitutes " (Oduolowu 1977). Although the objective defined above is highly commendable, the treatment of import substitution in the literature often has been associated with the negative image of inefficient operations protected from foreign competition by high tariffs and quotas. Import substitution industries have been equally charged with monopolistic pricing as a result of the lack of adequate competition, and have resulted in higher costs to the consumer. Also because import substitution focuses on the domestic market, the market's size can prevent the realization of economies of scale. Moreover, it has been observed that industrialization through import substitution often starts from the final goods and makes its way to primary inputs production through backward linkages. This means that in the first stage, intermediate inputs will have to be imported. If the protection measures taken to promote the domestic production result in massive imports of intermediate inputs, the objective of foreign currency savings, which is always one of those pursued, may be seriously compromised.

For all these reasons, there has been a lot of

disenchantment with the import substitution strategy. A more pervasive reason for disenchantment may lie in the fact that early development economists expected too much from it and from industrialization in general. For some, import substitution merely produced goods, although it was expected to change the whole social system (Hirschman 1968); for others, industrialization was believed to increase productivity in the other sectors of the economy by spillover effects (Hughes 1980).

Chronologically, import substitution was the first industrialization strategy to be experimented with. Without ignoring or minimizing the mistakes made in its implementation, the author believes it has been the target of undifferentiated criticisms. Consider the debate on protectionism. The argument advanced by the import substitution strategy proponents was the need for protection for the infant industry. The detractors of the strategy rejected it promptly because protectionist measures, once taken, tended to be permanent rather than temporary as they ought to be in the case of the infant industry case.

Is there a necessary link between import substitution and protectionism? Accepting the proposition implies that the industry born of the import

substitution strategy is not viable without protection. While it may be the case for some industries, it is hardly probable that it will be true for all of them: this would imply that the country has no comparative advantage in any commodity production.

It is probably against this undifferentiation that Bela Belassa addressed when he categorized import substitution into a "first stage" or "easy stage" and a "second stage" (Meier 1984). He defined the first stage as "entailing the replacement of the imports of non-durable consumer goods, such as clothing, shoes, and household goods, and their inputs ...."(Meier 1984). These commodities are appropriate to developing countries which do not have a substantial industrial base. They are unskilled labor intensive, and the optimal size of operations is rather small. The developing countries are at a relative advantage; little protection, if any, is required even in the infancy stage. The second stage of import substitution as defined by Bela Belassa concerns "the replacement of the imports of the intermediate goods and producer and consumer durables by domestic production" (Meier 1984). This includes such commodities as steel products and petrochemical products. These commodities require large

initial capital outlays and a market big enough to allow the production to take place at the optimal size. Yet DCs are chronically short of capital, and the domestic market for these commodities is generally small due to the lack of industrial base where they can be used as inputs. The second stage of import substitution, as referred to by Bela Belassa, is the one which is likely to be affected by the inefficiencies discussed above.

2.1.2 Export Oriented Industrialization Strategy

Export oriented industrialization is now the most advocated strategy; it refers mainly to manufactured exports rather than to the mere raw materials exports. This strategy has been credited with avoiding many of the shortcomings of import substitution industrialization. The strategy's most salient features are as follows:

-Because of its nature, it is not constrained by the size of the domestic market, and industries which do show increasing returns to scale are able to operate at the optimal size.

-Export oriented industries must produce goods which can compete in the international market; they cannot afford the luxury of inefficiencies in production.

The latter could occur, though, if those industries were benefiting from price subsidization mechanisms because of the DC government commitment to export. Nonetheless, many economists argue that price subsidization could not be extensive because its cost would appear directly in the budget. This would be less sustainable than a same level of protection in the case of import substitution.

The success of the strategy was indicated by the high growth rates of the export manufactures from the DCs which "reached an average annual growth rate of 12.3 percent from 1960 to 1976, while the growth rate was approximately 8.8 percent for the developed countries" (Meier 1984). As is often the case, relative rates are misleading if they are given without reference to the relevant absolute values. Indeed, despite such vigorous growth rates, the value of all manufactured exports of DCs was $33.2 billion in current U.S. dollars representing less than 7 percent of the total world trade value, $498.9 billion in current U.S. dollars (Meier 1984). Since about 65 percent of that $33.2 billion was attributed to only eight of the leading DCs in this strategy, the question is whether there is enough room for every DC to engage in systematic

manufactures export oriented industries. An examination of Table 2-1 shows that this will be rather difficult if not impossible. If one assumes that the structure of world trade in manufacture will remain the same with about 60 percent of DC exports going to the developed or industrialized countries, the developed countries would not be able to absorb the additional capacity. The reason is that additional imports by the developed countries would mean additional loss of jobs in related industries in developed countries. The only way developed countries can accommodate imports from DCs is by creating new industries where those workers displaced from their jobs by the comparative advantage of the DCs can be employed. This implies that the export-led industrialization in DCs appears to be constrained to proceed at the same pace at which creation of new industries in developed countries takes place.

This is a serious limitation since adoption of existing technology proceeds at a much quicker pace than does creation of new technology. Failure to match the speeds of the two processes will result in developed countries enacting protectionist laws and regulations as is evidenced by the now common practice of "voluntary export restrictions" on cars and steel products and the

Table 2-1

Matrix of World Trade in Manufactures

1976

(billion U.S. dollars)

Exports From/To	Developed	(Part to) Europe	Developing	Centrally Planned	World Total
Developed	321	(224)	121	27	469
(of which					
W. Europe)	(226)	(193)	(61)	(20)	(307)
Developing	28	(10)	14	3	45
Centrally Planned	9	(8)	7	34	50
World Total	358	(242)	142	64	564

Source: Meier, G.M. 1984 Leading Issues in Economic Development, fourth edition, Oxford: Oxford University Press, 1984, p. 527.

widespread "restraints" on textile imports in the event of a "market disruption." A market disruption is defined as "a sharp and substantial increase in imports of a particular item; import prices substantially below domestic prices in the importing country and serious damage to domestic "producers" (Meier 1984). It would be naive to think that the world is ruled by economists whose aim would be to see that trade takes place in an efficient way; cheap manufactures imports from DCs are welcome in the developed countries only if they do not result in unemployment or low wages in DCs. In looking at Table 2-1 one wonders why the DCs could not capture the share of the developed countries exports to the DCs. There would not be any unemployment problem within the DC which would replace only a developed country source of import by a DC source of import. The $121 billion manufactures exports represent more than four times the total value of the DCs manufactures exports. More of the marketing effort of DC manufactures exporters should be directed towards other DCs. There are, however, some problems in this direction also. On one hand DCs import capacity is presently constrained by the debt burden and stagnant export earnings. On the other hand, a major portion of DCs import capacity is provided by the

developed countries aid and export promotion agencies and therefore cannot be used towards the import of goods from other DCs.

2.1.3 The Coefficient of Domestic Factors Intensity in the Industrialization Process

From the above discussion, it can be seen that there is no easy way to industrialization. The shortcomings of the import substitution strategy have been known for a long time, and the limitations of the export oriented strategy are now starting to appear.

There should be no false dichotomy between the two strategies. There is no reason why a DC could not encourage the substitution of those commodities it imports but can produce more cheaply domestically while promoting the export industries for those commodities in which it has a comparative advantage. Moreover, some industries could be gainfully designed for both the domestic and the foreign market, a move which would tend to minimize the bias towards any of the markets. And even for those DCs emphasizing export oriented growth, their greatest potential for growth lies in the industrialization of the other DCs.

The two strategies can be reconciled as outlined below.

Definitions:

X_j^* is the generic product of the modern domestic components of the economy.

X_j^* is a functional substitute for X_j; emphasis is placed on "functional": X_j^* does not need to be the same product as X_j, it is enough that it can replace X_j in its uses, or vice versa, d units of X_j^* being equivalent to f units of X_j. Moreover, X_j need not be imported presently, even though it may be. All that is assumed is the freedom for domestic and foreign consumers to switch to either X_j^* or X_j in response to their relative prices.

CX_j^* is the FOB plant cost of X_j^*

PX_j is the CIF price of X_j before imposition of any tax.

If transportation costs within the DC are ignored, the efficiency conditions for the industrialization imply

$$dCX_j^* < fPX_j \quad \text{or} \quad CX_j^* < (f/d)PX_j \tag{2}$$

The production function of X_j^* can be expressed in general terms as

$$X_j^* = X_j^* (D_1, D_2, \ldots D_k, \ldots D_m, F_1, F_2, \ldots F_l, \ldots F_n)$$

where the D_k and the F_l represent the domestic inputs and the foreign inputs in the production of X_j^*.

By definition:

$$CX_j^* = \sum_{k=1}^{m} d_k PD_k + \sum_{l=1}^{n} f_l PF_l \qquad (3)$$

where d_k is the amount of units of domestic input D_k used in the production of one unit of X_j^*.

PD_k is the competitive price of D_k in the domestic economy or what its CIF price would be if it was to be imported.

f_l is the amount of units of foreign input F_l used to produce one unit of X_j^*.

PF_l is the CIF price of F_l.

The ratio of the expenditures on the domestic factors to the total expenditures is defined as the coefficient of intensity of use of domestic factors.

$$\rho = \frac{\sum_{k=1}^{m} d_k PD_k}{\sum_{k=1}^{m} d_k PD_k + \sum_{l=1}^{n} f_l PF_l} \qquad (4)$$

In general

$$0 < \rho < 1$$

the extreme cases being

$\rho = 0$ for an imported good

$\rho = 1$ for a good produced with domestic inputs only

If one assumes that returns to factors are based equitably on the expenditures on those factors, ρ is also a measure of the returns to the domestic factors. Therefore, the aim of the DC policymaker will be to maximize ρ while satisfying the conditions for efficiency, i.e.,

maximize ρ

subject to $CX_j^* < (f/d)PX_j$

The proper use of ρ assumes that there is no bias or distortion in the market of production factors between domestic and foreign inputs. It is better to make the assumption in order to keep the model simple and to account for the distortion once its magnitude and direction are known. The bias or distortion occurs generally as a secondary effect of attempts to save some foreign currency or in attempting to increase the foreign currency earnings.

First consider the bias towards lower costs of

domestic inputs relative to the costs of foreign inputs. The production function is fixed, and the prices of the foreign inputs are out of the control of the DC policymakers. If $CX_j^* > (f/d)PX_j$, the only way in which the direction of this inequality can be reversed is by lowering the costs of the domestic inputs through a price regulation system. This would occur in the case of a DC government trying to promote export or initiating an import substitution industry that it wants to present as economically attractive. The value of ρ will move towards zero indicating an industrialization with less than potential returns to the domestic factors, and domestic resources will have been used wastefully, i.e., in an uneconomical way.

The reason for the bias towards higher costs of domestic input compared to foreign inputs costs is less evident. At first glance, it is hard to see why a government would embark on a policy which results in higher costs of production and hence higher costs to domestic consumers and lower competitiveness in the international market. In fact, this is a rather undesirable side effect of policies aimed at other goals. One such a policy is currency overvaluation in order to pay less for the imported goods, the net effect

of which is a relative increase in domestic costs as compared with the costs of imported goods. Another policy which may result in the same situation is the discriminatory tariff for imports where some are "encouraged" and others are not. The encouraged imports are mostly connected in one way or another to an "encouraged" or protected industry. This results in an artificially higher value for ρ. By presenting those imports as cheap, this policy may delay the substitution of imports by products of the domestic economy. Moreover, this policy is likely to be pursued in those industries where the foreign inputs are already a major component of the overall product cost, i.e., where ρ is already small. Therefore this policy is likely to maintain the protected industry within the range of the low local value added. The assembly plants probably should be classified in this category.

Before the coefficient ρ can be used to qualify the industrialization process, the apparent possibility of a contradiction between the maximization of ρ and the maximization of GNP (i.e., X_j^* if this is once again taken as the generic domestic modern sector output) must be cleared. The contradiction can be illustrated as follows:

It is assumed that under the present supply conditions, the output is fixed at $\bar{X}_j^*$, $\rho = \bar{\rho}$ and $CX_j^* = (f/d)PX_j$.

For mathematical simplicity, expression (4) can be rewritten as

$$\rho = D/(D + F) \qquad (6)$$

where D is the aggregate cost of domestic inputs

F is the aggregate cost of foreign inputs

It is assumed that output of the modern sector Q_S is less than its demand Q_D by an amount ΔX_j^* because foreign capital F_C is in shortage. If an incremental foreign capital ΔF_C is supplied to the economy, the additional output ΔX_j^* could be produced at a cost $(\Delta D + \Delta F)$ at $\Delta CX_j^* = (f/d)PX_j$ but with

$$\Delta\rho = D/(D + F) < \bar{\rho} . \qquad (7)$$

If the production function of X_j^* displays the usual diminishing returns to scale with respect to the use of one single factor, expression (7) is likely to hold. Then the question is, which of the two variables ρ or X_j^* should be maximized in priority. Obviously X_j^* within the limits of the factors of production is the one to maximize in the first place. This can be shown in an

abbreviated form as

$$\text{maximize } X_j^*$$
$$\text{subject to } \bar{D},\ \bar{F} \qquad (8)$$

In expression (8) the bar over D and F means that the supply of factors of production is fixed. It is easy to understand that domestic factors of production, with the exception of unskilled labor, are limited, but why should the foreign inputs be limited in an open economy? On the one hand, DC command over foreign goods is limited by its foreign currency export earnings. On the other hand the amount of bilateral and multilateral aid is fixed on an annual basis or longer. Private investment is probably the only foreign input not formally fixed; however, competition among DCs for investment, and the DCs investment law ensure that the amount of private capital flowing to a DC is more or less fixed.

One may show that conditions (8) have priority over those in (5) by grouping them, conditions (8) being the outer ones, i.e.,

$$\text{maximize } X_j^*$$
$$\text{maximize } \rho$$
$$\text{subject to } CX_j^* < (f/d)PX_j$$
$$\text{subject to } \bar{D}\ ,\ \bar{F}$$

At each point in time, the DC policymaker is attempting to maximize X_j^* (GNP) by selecting the combination of inputs yielding the highest attainable for each incremental X_j^*. An aggregated ρ for the whole GNP will have little application. A coefficient ρ at a lower level of aggregation will be more useful.

2.2 Growth Through Increased Agricultural Productivity

An additional way of increasing the GNP is to increase the output of the traditional sector. Raising the productivity of the farmers will provide additional income which can be spent on industrial goods. For this process to happen, peasants must produce beyond the level of "strict subsistence," a surplus of products that they can trade for industrial goods. Since in most of the DCs, the subsistence sector D_T constitutes more than half of the GNP, a relative increase in D_T will induce higher relative increases in the other components of the GNP. Along the same lines J.W. Mellor estimates that "because demand patterns are skewed towards nonagricultural goods and services, those other sectors, when stimulated by agriculture will accelerate to 10-15 percent growth rates compared to the 4 percent considered remarkable in agriculture" (Meier 1984).

Where water is scarce, dam construction would improve productivity; elsewhere, the introduction of better seeds and the use of insecticides and fertilizers would benefit agriculture. The "revolution" calls for a dramatic change in the peasant production function. The analysis done above on the domestic factors intensity of industrialization cannot be duplicated for agriculture.

CHAPTER 3

IMPORTANCE OF INDUSTRIAL MINERALS IN ECONOMIC GROWTH

3.1 Definition, Characteristics, and Classification of Industrial Minerals

3.1.1 Definition

An industrial mineral is "any rock, mineral or other naturally occurring substance of economic value, exclusive of metallic ores, mineral fuels, and gemstones; one of the nonmetallics" (Bates 1980). While the distinction between fuel minerals and the other minerals is fairly clear, the cutoff between the metallic and the nonmetallic, nonfuel minerals is less obvious. Bates in his introduction to Industrial Minerals and Rocks (1983) gives the examples of bauxite (aluminum ore) and ilmenite (titanium ore) as minerals which qualify as metallic ores and also as industrial minerals (refractory and abrasive for bauxite and pigments for ilmenite). Manganese ore and chromite are other straightforward examples. But in a strictly scientific sense, the reactive metals such as calcium or sodium, which are more relevant to the "chemical industry" than to the "metallurgical industry," are produced from industrial minerals. It appears that the

end use of the raw material is more important than its content. Even if the lack of a clear-cut definition is put aside, industrial minerals are a wide variety of commodities. In Industrial Minerals and Rocks which appears to be the "bible" on the subject, 46 of the most important commodities are reviewed and classified in 14 major end uses. Bates had a highly suggestive comment: "We may say paradoxically that diversity is about all they have in common."

3.1.2 Characteristics

While keeping in mind that there are many significant exceptions, industrial minerals do have some common characteristics. The most important are reviewed below:

a) Abundant Commodities

Industrial minerals are relatively abundant. In this respect it is interesting to note that there are no explicit reserve base figures for sand and gravel, stone, clays, feldspar, lime, or gypsum in the Mineral Commodities Summaries (U.S. Bureau of Mines 1984). The reserves are judged adequate for all countries. In fact, the only limitations imposed on the mineable reserves, in most cases, originate from the national, regional, or local regulations such as zoning,

environmental restrictions, and the like. The theoretical reason underlying this abundancy is that industrial minerals, at least those mined in high tonnage, are combinations of the most abundant chemical elements in the composition of the earth's crust as shown in Table 3-1. For instance, sand is composed mainly of silicium dioxide thus involving the two most abundant elements. Clays are hydrous alumino-silicates, thus involving the first three most abundant chemical elements. Stones are mostly granitic or basaltic rocks, the two principal igneous rocks which form more than 90 percent of the earth's crust. Caution must be exercised in making general statements relating to such a diverse group of materials. First, even for relatively abundant elements, the degree of concentration required to make a deposit economic may be so high that there are few exploited deposits in the world. This seems to be true in the case of potash which is rather scarce even though potassium is quite abundant in common rocks. Second, while chemical composition is important, physical properties may be even more important. The materials which are mainly sought because of their special physical properties, acquired them under very localized conditions and are therefore rather scarce. An example

Table 3-1

Average Abundances of Elements in the Earth's Crust in Three Common Rocks, and in Seawater

(in parts per million)

Element	Crust	Granite	Basalt	Shale	Seawater
O	46.4×10^4	48.5×10^4	44.1×10^4	49.5×10^4	880,000
Si	28.2×10^4	32.3×10^4	23.0×10^4	23.8×10^4	2
Al	8.1×10^4	7.7×10^4	8.4×10^4	9.2×10^4	0.002
Fe	5.4×10^4	2.7×10^4	8.6×10^4	4.7×10^4	0.002
Ca	4.1×10^4	1.6×10^4	7.2×10^4	2.5×10^4	412
Na	2.4×10^4	2.8×10^4	1.9×10^4	0.9×10^4	10,770
Mg	2.3×10^4	0.4×10^4	4.5×10^4	1.4×10^4	1,290
K	2.1×10^4	3.2×10^4	0.8×10^4	2.5×10^4	380
Ti	5,000	2,100	9,000	4,500	0.001
H	1,400	–	–	–	110,000
P	1,100	700	1,400	750	0.06
Mn	1,000	500	1,700	850	2×10^{-4}
F	650	800	400	600	1.3
Ba	500	700	300	600	0.002
Sr	375	300	450	400	8.0
S	300	300	300	2,500	905
C	220	320	120	1,000	28
Zr	165	180	140	180	3×10^{-5}
Cl	130	200	60	170	18,800

Source: Krauskopf, K.B. 1979 Introduction to Geochemistry, second edition, New York: McGraw Hill Inc.

is diamonds, which are sought for the hardness that will be more abundant and cheaper. Synthetic material carbon acquired under severe temperature and pressure conditions. Another example is specialty clays, prized for their plasticity and expandability.

b) Low Value, High Tonnage Commodities

Since most industrial minerals do not enjoy scarcity premiums,their prices tend to be rather low, and they are used in much larger tonnages than are metallic ores. Table 3-2 illustrates the 1978 per capita consumption in the United States for some important commodities.

c) Commodities Which Cannot Afford Long Transportation Distances

In general, the most important factor determining the maximum transportation distance for a commodity is its price per unit of weight. Additional constraints on transportation distance are geographical distribution and the prices of substitutes. The more geographicaly widespread a commodity is, the shorter the transportation distance. Common industrial minerals, e.g., sand and gravel and crushed stone, are so widespread that the geographical factor predominates. At going prices of less than US$5/ton, there seem to be no

Table 3-2

Per Capita Consumption of Selected Metallic and Nonmetallic Commodities in the U.S.A

Nonmetals		Metals	
Stone (crushed)	9,140 lbs	Steel & Cast Iron	1,205 lbs
Sand & Gravel	8,580 lbs	Aluminum	55 lbs
Cement	800 lbs	Copper	23 lbs
Clays	490 lbs	Lead	14 lbs
Salt (NaCl)	440 lbs	Zinc	12 lbs
Phosphate rock	310 lbs	Manganese	14 lbs
Others	1070 lbs	Other metals	19 lbs

Source: Prepared by Rudawsky, O., 1984, Colorado School of Mines

possible substitutes. No alternative natural substitutes will likely use a higher cost raw material and will also have to bear the cost of processing. Typical truck haulage distances are shown below for crushed stone, lightweight aggregate and sand and gravel.

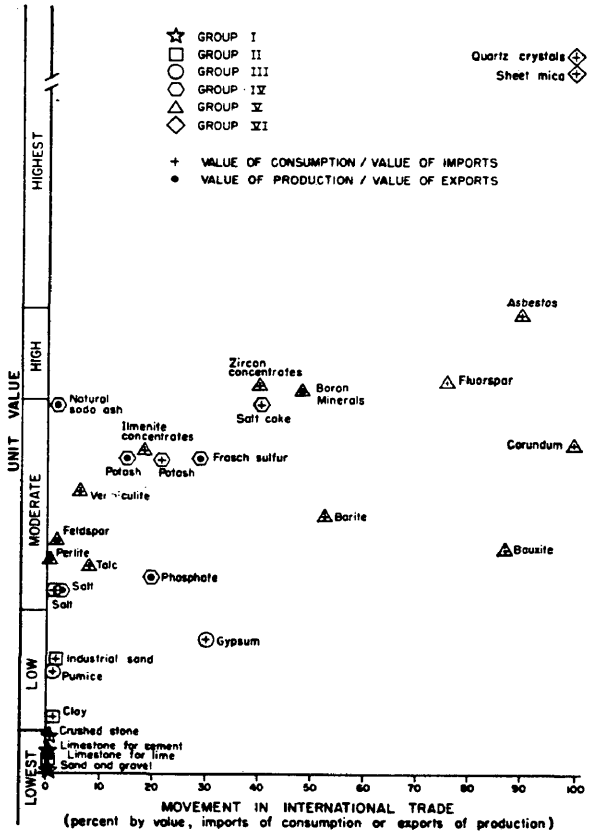
- crushed stone: about 20 - 30 miles (Schenk and Thorries 1983)
- lightweight aggregate: less than 50 miles (McCarl 1983)
- sand and gravel: about 20 miles (Dunn 1983)[1]

The short transportation distances make common industrial minerals local commodities or, at most, regional ones. This is illustrated in Figure 3-1 which shows the relationship between movement in international trade and unit value for the United States. Although the unit value scale is somewhat arbitrary, Figure 3-1 shows that only moderate to high value commodities are entering the international trade. Gypsum, which seems to be significantly traded even though it is a rather low-price commodity (currently about US$ 9/st), is an easily explained exception since almost all U.S. imports

[1]Typical transportation distances are not given in Industrial Minerals and Rocks. Average transportation costs are given: 35 cents/ton for the first mile and 10 cents/ton for each additional mile. These figures will exceed the US$ 3/ton price of sand and gravel at a distance of 27.5 miles.

Figure 3-1

Relationship Between Trade and Unit Value for the United States



Source: Fisher, W.L. 1969 "The Nonmetallic Industrial Minerals: Examples of Diversity and Quantity," Mining Congress Journal, February, p. 123.

are from neighboring Mexico and Canada. These two countries accounted for about 95 percent of U.S. gypsum imports for the period 1979-1982.

3.1.3 Classification

Many classifications have been proposed to cope with the variety of industrial minerals; the most acknowledged are those by Bates (1960), Wright and Burnett (1962), Fisher (1969), Kline (1970), and Dunn (1973). They differ on the relative emphasis placed on economic, geological, and end use criteria. The basis of the Bates classification, which splits industrial minerals in two groups, is shown in Table 3-3.

The most sophisticated classification has been elaborated by Fisher. He distinguishes six groups.

Group I Bulk construction and building materials (e.g., sand and gravel).

Group II Bulk ceramic materials, lime raw materials, and secondary products (e.g., ceramic clay and limestone).

Group III Specialty building materials and principal refractories (e.g., gypsum and fire clay).

Group IV Major industrial process, chemical, and fertilizer raw materials (e.g., sulfur).

Table 3-3

Basis of Bates Classification of

Industrial Minerals

Aspect	Group 1	Group 2
Bulk	Large	Small
Unit Value	Low	High
Place Value	High	Low
Imports & Exports	Few	Many
Distribution	Widespread	Restricted
Geology	Simple	Complex
Processing	Simple	Complex

Source: Bates, R.L. 1969, Geology of the Industrial Rocks and Minerals , New York: Dover Publications, Inc. p. 17

Group V Industrial rocks and minerals (e.g., fluorspar and talc).

Group VI Specialty grade and precious rocks and minerals (e.g., industrial crystals).

The list of commodities included in each group is given in Table 3-4. In order to support his classification, Fisher developed graphs based on empirical U.S. data relating unit value to such variables as

- ratio of units of ore to units of marketable product
- average annual production per mine and mill employee
- number of operating mines
- movement in international trade

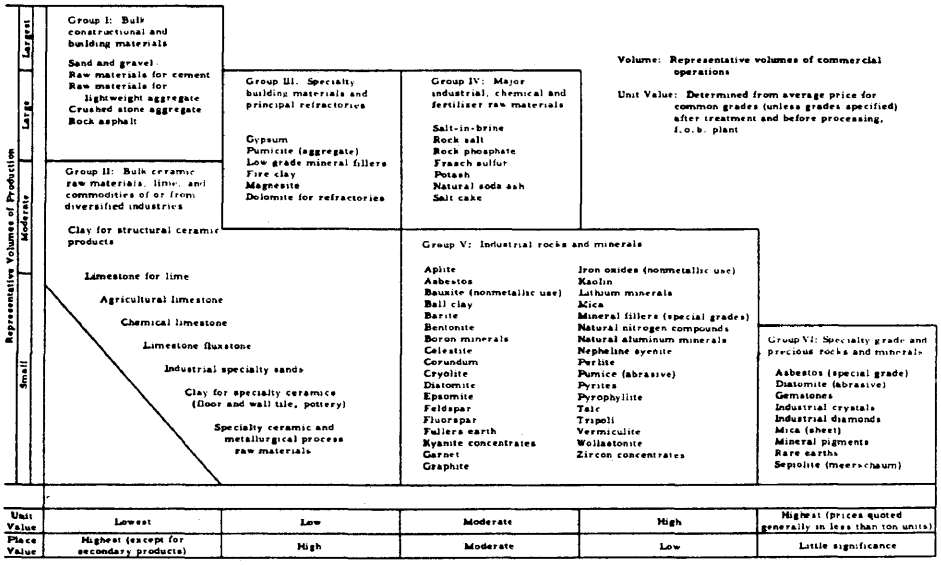
It is probably the most extensive classification without falling into the excess of being an enumeration of end uses.

This study will focus on commodities meeting three criteria:

- Commodities mined primarily for local use as opposed to those exploited for the export market.
- Commodities undergoing a reasonable degree of processing.

Table 3-4

Fisher's Classification of Industrial Minerals



Source: Fisher, W.L. 1969 "The Nonmetallic Industrial Minerals: Examples of Diversity and Quantity," Mining Congress Journal, February, p. 123.

- Geographically widespread commodities.

This study excludes commodities mined primarily for export because their economic and policy aspects are not different from those of metal mining. Export commodities call for devising a mean of attracting investment, especially foreign, while ensuring an adequate rent to the DC. Most of the DCs have already enacted sophisticated mining legislation to fulfill that goal. In terms of the Fisher classification, commodities excluded by this criterion belong mostly to the Group VI and include among others, diamonds, precious stones, rare earth, and high quality asbestos.

Commodities in Group I, with the exception of cement raw materials, do not require significant processing. There is no need to break down doors here; governments and private enterpreneurs are doing fairly well in this field. There is no foreign competition and no supply problem. There may be some room for improving the multiple land use objective, especially in densely populated areas. Such a purpose would be served by a mineral inventory of the area under consideration. The identified mineralized zones should not be used for activities which would result in those zones being lost to mining. Worked out mine sites should be reclaimed for

agriculture, construction, or recreational purposes. Processing increases the unit value of the raw material and can make it enter the international market. If developing countries do not pursue adequate policies, they may find themselves importing commodities that they could produce domestically, or even export competitively. Industrial minerals considered as widespread are those found in most countries. This ubiquitous criterion rules out most, if not all, of Group IV commodities. The core of commodities on which this study focuses is Group II commodities, cement raw materials, and some commodities from groups III and V of the Fisher's classification.

3.2 The Industrial Minerals in Economic Growth

3.2.1 The Importance of Industrial Minerals

One customary way of illustrating the importance of a sector in the national economy is to show its contribution to the gross national product or to compare its contribution with those of the more publicized sectors. In 1982, the U.S. nonmetal, nonfuel mineral output was valued at U.S.$14.147 billion, which is much greater than the U.S.$5.544 billion for metal production. Of that U.S.$14.147 billion, cement, sand

and gravel for construction and stone, together, accounted for U.S.$ 7.976 billion; thus showing the preponderance of the construction sector as the biggest recipient of industrial minerals production (U.S. Bureau of Mines 1982). Other major uses sectors were the chemical, fertilizer, metallurgical, glass, and ceramics industries.

The fact that the value of nonmetals, nonfuels mining output outweighs metal mining is not peculiar to the United States. The average ratio of nonmetallic mine production value to the metal mine production value for the 33 countries for which it could be calculated was 2.131, as shown in Table 3-5. The average ratio was found to be statistically greater than 1 at a 95 percent confidence level. Nonetheless, if nonmetal is the major component of the mining sector, one should keep in mind that it represents only 5.5 percent of the value in the world economy[2]. This contribution is unevenly distributed, 2.6 percent in the developed market economy countries and 14.2 percent in the developing countries (Callot 1980).

[2]As defined here, mining excludes quarry products such as stone, sand, and gravel; thus in reality the figures of the contribution of mining to the economy are higher than those quoted.

Table 3-5

Ratio of Value of Nonfuel-Nonmetal Minerals Production to the Value of Metal Production

Country	Ratio	Year
Australia	0.181	1980
Austria	3.207	1980
Canada	0.249	1980
Costa Rica	3.231	1980
Cyprus	5.437	1980
Czechoslovakia	0.834	1980
Dominican Republic	0.043	1977
Ecuador	7.260	1979
Fiji	0.157	1979
Finland	0.375	1980
France	8.789	1980
Greece	4.238	1979
Hungary	0.638	1980
India	1.149	1980
Ireland	2.429	1978
Italy	2.217	1980
Japan	1.963	1980
Korea (South)	1.662	1980
Mauritius	0.447	1980
New Zealand	1.923	1980

Table 3-5 (con'd)

Ratio of Value of Nonfuel-Nonmetal Minerals Production to the Value of Metal Production

Country	Ratio	Year
Norway	0.886	1980
Peru	0.175	1977
Philippines	0.054	1977
Poland	3.561	1980
Portugal	2.368	1980
Spain	1.568	1980
Sweden	0.154	1980
Tunisia	9.699	1980
Turkey	0.958	1979
United Rep. Cameroon	0.083	1980
United States	2.817	1980
Yugoslavia	0.727	1980
Zimbabwe	0.832	1978

Source: (a) World Bank 1980 World Tables, second edition, Baltimore: The Johns Hopkins University Press.
(b) United Nations 1983 Yearbook of International Trade Statistics, 1981 edition. New York: United Nations Publication, Volume 1.
(c) United Nations 1983 Yearbook of Industrial Statistics, 1981 edition, New York: United Nations Publication, Volume 1.

Disagreement exists about whether the value of mine output is a fair measure of the role of the mineral industry in the world economy. The major criticism is that it fails to account for "the considerably enhanced value that results from beneficiation, smelting, refining, and other equivalent downstream processing " (U.S. Bureau of Mines 1982). All that is needed to end the disagreement is a clear cut-off point between mining and manufacturing. But the value of output generated through further processing cannot be attributed totally to the mining output since there are other factors of production. Nevertheless, industrial minerals play a vital role because they are the raw materials for most of the manufacturing and the fertilizer industries; their market values are a good approximation of the value society places on them for fulfilling that role.

3.2.2 Self-Sufficiency in Industrial Minerals Products

In the previous chapter, a coefficient ρ was developed to measure the adequacy of industrialization in terms of the intensity of domestic factors use. If the inputs are aggregated in capital (K), labor (L), and raw materials and intermediate inputs (R), ρ can be rewritten as

$$\rho = \frac{d_1K_d + d_2L_d + d_3R_d}{d_1K_d + d_2L_d + d_3R_d + f_1K_f + f_2L_f + f_{3Rf}}$$

where the subscripts d and f refer to domestic and foreign inputs. The coefficient can be seen as an aggregation of three coefficients:

$$\rho_K = \frac{d_1K_d}{d_1K_d + f_1K_f} \qquad \rho_L = \frac{d_2L_d}{d_2L_d + f_2L_f} \qquad \rho_R = \frac{d_3R_d}{d_3R_d + f_3R_f}$$

This suggests three alternatives for increasing the overall .

a) Increasing ρ_K

Practically, this is the least feasible way since capital is in rather short supply in the DCs. It is desirable to lower ρ_K if the aim is to put more local labor and raw materials in production which would otherwise have remained idle. The only time that ρ_K should be increased is when foreign exchange regulations, are lenient causing domestic capital to flow out of the country. In that case, government would be well advised to enact more stringent regulations pertaining to foreign exchange. However this seems to proceed more from theory than from any known case; all DCs having rather restrictive regulations in this field.

b) Increasing ρ_L

This is certainly desirable. Practically this will be achieved through the replacement of foreign labor by national labor. DC governments are aware of the problem and measures taken in this respect will bring results with time. Unskilled labor is readily available and skilled labor can be trained quickly. Developing countries already have such programs. Because of capital shortages even skilled labor is sometimes idle.

c) Increasing ρ_R

The most appropriate way of increasing ρ appears to be through a more intensive use of local raw materials and intermediate inputs. It is this author's opinion that DCs could benefit more than they do from their common industrial minerals resources endowment. In the rest of this chapter, the emphasis will be on the measurement of ρ_R value. If the value of ρ_R is found to be significantly less than 1, policies will be suggested to increase the ρ_R value.

a) Methodology for the measurement of ρ_R

A company purchaser buying from a local dealer cannot always distinguish between inputs of foreign origin from those of domestic origin. The appropriate place to measure the amount of foreign inputs is at the country border. The appropriate points for measuring the

domestic inputs are the dispatching bays of the domestic producing plants. Specifically ρ_R is approximated by the ratio of the domestic production to the sum of the domestic production and the net imports of the respective commodities. Should the country be a net exporter, the net import would be recorded as the negative value of the exports, so that the sum of the domestic production and the net imports always measures the domestic consumption. Then the coefficient ρ_R is also a measure of self-sufficiency in the commodities in question. Because this study focuses on intermediate products manufactured from cheap and ubiquitous raw materials, self-sufficiency is certainly desirable, and there is little room for arguing about trade and comparative advantage of certain countries over the others.

The data used for estimating domestic production are those reported by the United Nations under the headings:

-ISIC 361[3]: manufacture of pottery, china and earthenware

[3]ISIC is the abreviation for the International Standard Industrial Classification recommended by the United Nations Secretariat and now followed by most of the United Nations members.

-ISIC 362: manufacture of glass and glass products

-ISIC 3691: manufacture of structural clay products

-ISIC 3692: manufacture of cement, lime, and plaster

-ISIC 3699: manufacture of nonmetallic mineral products not elsewhere classified

The data used for the calculation of the net imports are those reported by the United Nations under the heading

-SITC 66[4]: Trade in non metallic manufactures

The self-sufficiency coefficient has been calculated for 52 countries for which data were available in usable form; the results are shown in Tables 3-6 and 3-7. Thirty-four countries had a per capita GNP inferior to U.S.$3,000 in 1977, and are classified in developing countries. Kuwait had a GNP of U.S.$12,690 in 1977 but is still a developing country; in order to be consistent with the GNP criterion for classifying countries into developed and developing countries, Kuwait has not been included in the

[4]SITC is the abreviation for the Standard International Classification recommended by the United Nations Secretariat and now followed by most of the United Nations members.

Table 3-6

Self-Sufficiency in Industrial Minerals Products in DCs

Country	Per Capita GNP in 1977 (a)	Net Imports (million US$) (b)	Production (million US$) (c)	%	Year
Bangladesh	80	38.889	36.054	48.11	1979
Ethiopia	110	11.960	18.551	60.80	1980
India	160	-125.657	1495.237	109.17	1978
Sri Lanka	160	14.888	46.423	75.72	1979
Rwanda	160	5.305	0.312	5.56	1977
Madagascar	230	7.290	9.904	57.60	1978
Togo	280	9.135	25.338	73.50	1979
Indonesia	320	126.362	488.393	79.45	1980
U.R. Cameroon	420	28.204	5.297	13.65	1978
Philippines	460	20.903	583.277	96.54	1979
Nigeria	510	554.615	331.327	37.40	1978
El Salvador	590	17.810	54.000	75.20	1978
Peru	720	-16.783	310.403	105.72	1980
Mauritius	740	27.235	17.227	38.75	1978
Colombia	760	-91.946	673.291	115.82	1980
Ecuador	820	98.095	132.080	57.38	1979
Guatemala	830	3.543	119.000	97.11	1978
Dominican R.	840	11.800	88.100	88.19	1980
Tunisia	840	83.280	362.291	81.31	1980
Syria	860	104.138	150.064	59.03	1980
Nicaragua	870	12.555	26.318	67.70	1980
Jordan	940	53.754	157.825	74.59	1980
Malaysia	970	101.999	58.664	36.51	1979
Korea (South)	980	-308.107	2,427.641	114.54	1980
Turkey	1,110	-36.762	1,252.427	103.02	1980
Mexico	1,160	-39.422	4,403.165	100.90	1980
Panama	1,200	18.082	59.000	76.54	1979
Chile	1,250	28.757	220.353	88.46	1978
Fiji	1,330	7.505	12.593	62.66	1980
Costa Rica	1,390	15.442	84.597	84.57	1980
Cyprus	1,830	-9.385	99.370	110.43	1980
Portugal	1,840	-58.366	996.041	106.25	1980
Malta	1,870	29.680	18.780	38.75	1980
Singapore	2,820	288.710	309.603	51.75	1980

Source: (a) World Bank 1980 World Tables, second edition, Baltimore: The Johns Hopkins University Press.
(b) United Nations 1983 Yearbook of International Trade Statistics, 1981 ed. New York, Volume 1.

Table 3-7

Self-Sufficiency in Industrial Minerals Products

in Developed Countries

Country	Per Capita GNP in 1977 (a)	Net Imports (million US$) (b)	Production (million US$) (c)	%	Year
Ireland	3,060	49.795	642.276	92.80	1980
Italy	3,530	-2,190.234	12,936.056	120.38	1980
New Zealand	4,480	45.234	462.945	91.10	1980
U. Kingdom	4,540	-311.197	15,250.597	102.08	1980
Finland	6,190	51.814	1,114.583	95.56	1980
Austria	6,450	-136.840	2,601.202	105.55	1980
Japan	6,510	-714.412	41,625.616	101.75	1980
Australia	7,290	277.792	3,373.082	92.39	1978
France	7,500	357.632	12,090.345	97.13	1980
Iceland	7,690	17.767	3,634.392	99.51	1980
Netherlands	7,710	450.130	2,761.155	85.78	1979
Canada	8,350	490.395	3,991.632	89.06	1980
Norway	8,570	161.643	901.544	84.80	1980
Germany (FR)	8,620	-270.873	19,397.652	101.42	1980
U. S. A.	8,750	2,233.274	46,400.000	95.41	1980
Denmark	9,160	-39.070	1,153.782	103.50	1980
Sweden	9,340	135.443	1,829.408	93.11	1980

Source: (a) World Bank 1980 World Tables, second edition, Baltimore: The Johns Hopkins University Press.
(b) United Nations 1983 Yearbook of International Trade Statistics, 1981 edition. New York: United Nations Publication, Volume 1.
(c) United Nations 1983 Yearbook of Industrial Statistics, 1981 edition, New York: United Nations Publication, Volume 1.

estimation of the coefficient ρ_R for the two groups of countries discussed below[5].

b) Calculated values for ρ_R

For the group of developed countries, the average value for the coefficient ρ_R ($\bar{\rho}_R$) was 97.137 percent with a standard deviation of 8.541 percent; at a 95 percent confidence level, it was not different from 100 percent, i.e., self-sufficiency.

For the DCs, the average value for the coefficient ρ_R ($\bar{\rho}_R$) is 73.31 percent with a standard deviation of 28.63 percent; at a 95 percent confidence level, it was significantly less than 100 percent. At the same confidence level, the DCs are less self-sufficient than the developed countries. The high values for the coefficient in both groups confirm that industrial minerals, even when processed, are still relatively low unit value commodities of which only a small portion enter the international trade.

The shortcomings of the coefficient ρ_R calculated above lie essentially in the level of aggregation of the data used. First they encompass the production and trade of intermediate goods (cement, glass) as well as final

[5]The GNP figures used here are derived from the World Tables published for the World Bank by The Johns Hopkins University Press, 1980 edition.

goods (i.e., glass recipients). Second, while the aim was to measure ρ_R for the common and processed industrial minerals, the way the data are presented does not allow the exclusion of such rare industrial minerals as diamonds and precious and semi-precious stones. Fortunately, among the countries studied, only India and Indonesia reported a rather minimal diamond production for the years in which the coefficient was calculated. If India's trade in diamonds is taken into account, the value of ρ_R for India would change from 109.17 percent to 109.58 percent, assuming all the diamond production was consumed domestically. Under the same assumptions, the value of ρ_R for Indonesia will fall from 79.45 to 77.41 percent. If one makes the more realistic assumption that at least part of the production was exported, the impact would be even smaller, so that the conclusions reached above remain valid.

In the next chapter, alternative measures available to the DCs for increasing the production of industrial minerals products will be examined.

CHAPTER 4

MEASURES TO PROMOTE THE INDUSTRIAL MINERALS SECTOR IN THE DEVELOPING COUNTRIES - THE SPECIAL CASE OF CONSTRUCTION MINERALS

4.1 The Importance of the Construction Sector to the Industrial Minerals

In the previous chapter, the construction, glass, and ceramics industries were found to be the major markets for the industrial minerals on which this study focuses. They were defined by three characteristics, undergoing a reasonable degree of processing, geographically widespread and the local end use. When one realizes that most of the glass and ceramic products find their ultimate uses in the construction sector, this sector becomes the major market for the common industrial mineral of interest to this study. In addition, the construction sector is also the end use of a variety of industrial minerals ranging from the common sand and gravel to less abundant materials like gypsum and pumicite. Therefore the choice of the construction sector as the market the most relevant to the industrial minerals is amply justified.

The construction sector is vital not only for the industrial minerals for which it provides a market but

also for the national economy. This is the ultimate justification of the importance of these industrial minerals. Until recently, the construction sector did not attract much attention from the development economists. The Athens Symposium on Industrial Development sponsored by the United Nations Industrial Development Organization (UNIDO) identified among others the following causes for this apparent neglect.

- the small size of production units which complicates the collection of data.
- the extensive degree of subcontracting with the accompanying risk of double counting and omissions.
- the existence of a large nonmonetary component in the construction sector whose output is difficult to measure numerically and more importantly to value.
- the dilution of the construction component in other sectors of the economy.

However those accounting problems were not insoluble and the construction sector is now reported separately in national statistical data. Moreover, the importance of the construction sector has been finally acknowledged in national and international forums on

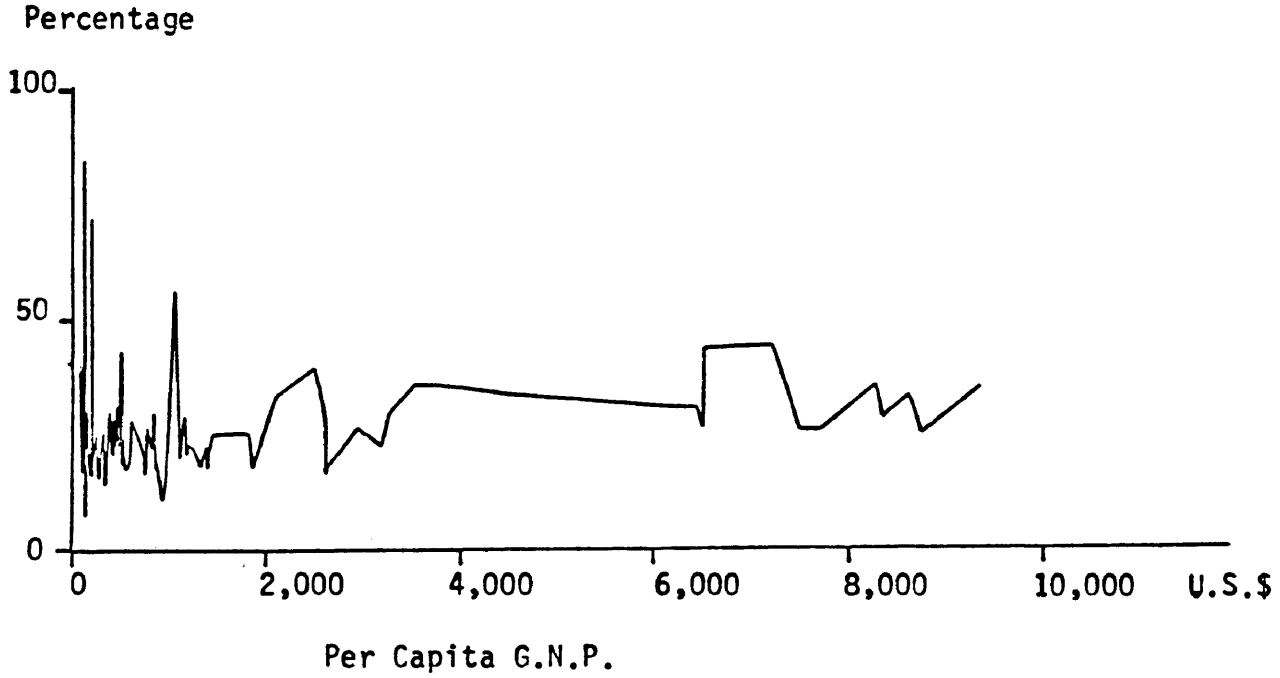
development issues. One major step in this direction was the United Nations Lima Declaration. There, it was recognized that the DCs objective of bringing their share of world manufactured goods output to 25 percent by the year 2000 would be difficult, if not impossible, to achieve without a substantial increase in the construction output. Another step forward was the high priority given to the construction sector, second to only food production, by the Organization of African Unity action plan elaborated by the Council of Ministers in Lagos in 1980. With the exception of repair and maintenance work, the output of construction constitutes an integral part of the gross domestic investment in the national accounts.

In order to illustrate the importance of the construction sector in the economy, the ratio of the construction output value to the gross domestic investment as well as its share in the gross domestic product have been calculated for 97 countries. The average ratio of the construction output to the gross domestic investment was 25.98 percent with a standard deviation of 11.04 percent (see Appendix 1 for details). This ratio has been plotted against the GNP in Figure 4-1 and, surprisingly there is no apparent

Figure 4-1

Ratios of the Construction Output to the

Gross Domestic Investment



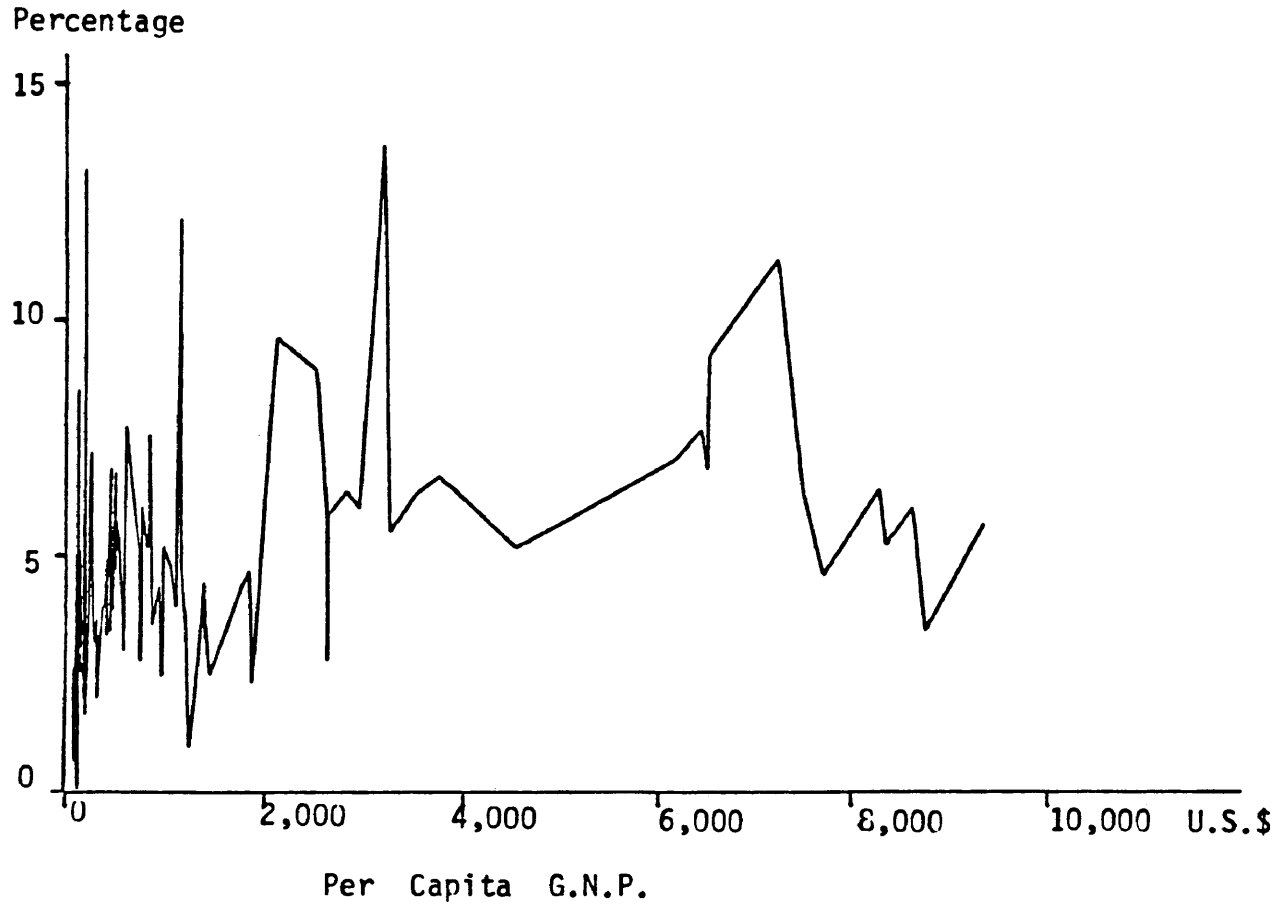
Source: World Bank 1980 World Tables, second edition, Baltimore: The Johns Hopkins University Press.

relationship between the two variables. One would have expected the ratio to be greater in countries in the early stage of the development process, i.e., at lower GNP figures. Most of the infrastructure is being established, and it has a high component of civil engineering. The average share of the construction output in the gross domestic product was 6.01 percent with a standard deviation of 2.54 percent. This statistic has been also plotted against the GNP in Figure 4-2 and once again there is no apparent relationship between the two variables.

In the countries examined, the construction sector accounts for about 25 percent of the gross domestic investment. Any significant improvement in that sector will spillover on the whole investment component of the GNP. This study focuses on improvement caused by a better supply of the industrial mineral products. Table 4-1 displays a representative composition of construction inputs in a typical DC in the 1960s (UNIDO$_a$ 1969). In Table 4-1, agriculture, mining, and manufacturing inputs are lumped together and account for about 40 percent of the total gross value of production. Out of that 40 percent, 60 percent was imported. Even though DCs have sensibly increased their domestic

Figure 4-2

Ratios of the Construction Output to the Gross Domestic Product



Source: World Bank 1980 World Tables, second edition, Baltimore: The Johns Hopkins University Press.

Table 4-1

Profile of Construction Inputs in a Typical DC in the 1960s

(gross value of production equals 100 units)

	Domestic	*Indirect imports*	*Direct imports*	*Total*
Inputs from agriculture, forestry, mining, quarrying and manufacturing ...	16	8	16	40
Fuel, power, electricity, gas, water	1	1	—	2
Other service inputs, including transport	8	4	1	13
TOTAL VALUE OF INTERMEDIATE INPUTS	25	13	17	55
Wages and salaries and associated expenditure	28	—	3	31
Amortization of plant and equipment and rentals paid	—	—	2	2
Indirect taxes less subsidies	2	—	—	2
Other gross business income	8	—	2	10
TOTAL GROSS VALUE OF PRODUCTION	63	13	24	100

Source: UNIDO 1969 Industrialization of Developing Countries: Problems and Prospects. New York: United Nations Publication, Volume 2, p. 19.

production of industrial minerals products, they still have a greater dependence on imports of these materials than the developed countries. The preponderance of the construction sector in DCs imports of industrial minerals products is marked. As a matter of fact, the average ratio of the building materials imports value (SITC 661 and SITC 662) to the value of all industrial minerals imports (SITC 66) was calculated for 122 countries and territories and was equal to 50.29 percent with a standard deviation of 23.37 percent. However the ratio was unevenly distributed. For the 39 African countries and the Reunion Island included in the survey, the average ratio was 60 percent while it was only 18 percent for the eight developed countries considered (see Appendix 2 for details). Actually, the value of the ratio would be greater if the glass imports were included. The industrial minerals products for construction represent a major component of the industrial minerals import and a policy should be designed in order to reduce reliance on imports for these materials.

A policy for self-sufficiency is justified not only because of the foreign currency savings that can be achieved, but also because of the additional beneficial

impacts on the remainder of the economy. Cheap local building materials are especially critical to the success of the rural development policies being pursued by almost all the DCs. The objective of these policies is to meet the basic needs of the rural populations and to bring them some of the amenities available to urbans but lacking in the rural areas; this would permit the control of urban migration and campaign depopulation. Practical objectives include the construction of schools, hospitals, water wells, irrigation channels, electrification, etc. The construction of these infrastructures are conditional to the availability of cheap building materials; otherwise they would become unaffordable for the rurals they were intended for.

4.2 Major Considerations for the Promotion of Local Production of Building Minerals

4.2.1 Availability of Raw Materials

The first duty of whoever is entrusted with the responsibility of developing the local building materials industry will be the establishment of a sound inventory of the raw materials occurrences. It may sound paradoxical to stress this requirement for commodities which are considered widespread. But planning would not

be possible without detailed enough information on the raw materials available in terms of quality and quantity. However, a compromise must be reached between the quality of the requested information and the reasonable cost of obtaining it. While a thorough and detailed inventory of high value minerals occurrences in the country is warranted, it is not feasible to have lime, clays or sand deposits investigated in the same degree of detail. Fortunately, most of the DCs have launched or completed the production of the country geological map. As a side benefit of this mapping, all the economically significant occurrences encountered during the mapping process will be reported on the map. By economically significant it is meant that on a preliminary basis, the reserves are worth further studying in order to determine their suitability to sustain an economical operation.

This is certainly a good starting point but very rarely will these data be adequate as far as minimum proven reserves and raw materials behavior during processing are concerned. Very likely, further drilling and testing will be necessary before the feasibility study can be undertaken. Most of the lime, clay, and sand deposits, being sedimentary rocks will be found

close to the surface and the drilling and sampling will be relatively cheap. For the same reason, exploitation is generally carried out by open pit methods which are cheaper than underground ones. Small deposits which cannot sustain a large operation may find uses on a small level.

> Localized outcrops or occurrences of very little economic significance, and too small to be marked on available geological maps, may nevertheless yield sufficient quantity of material to supply a village-scale industry for many years. There are many such occurrences still to be described (Spence 1978).

It is safe to assume that increasing the exploration efforts will lead to new discoveries; however, these discoveries will be more likely on virgin lands. For those areas which have been already explored in some detail, DC governments, within the limits imposed by their meager budgets, are quick in taking the adequate measures to bring into production those deposits which appear to be technically and economically feasible on the basis of established technology.

Additional production of building materials of industrial mineral origin will be achieved by bringing into production those known deposits which are judged too small to be usable by a conventional size plant. This is more easily said than done. The fact that these

deposits are not currently exploited suggests that a significant problem exist and must be dealt with. Solutions must be found and the government role must be determined.

4.2.2 Choice of the Production Scale

Since these commodities are characterized by an unfavorable value to weight ratio, it is always preferable to set the production plants as close to the markets as possible.Geographically concentrated demands, such as urban areas, should be served by large scale plants which minimize the transportation distances and take advantage of the economies of scale. Scattered rural demand should be met by adequately sited small scale plants which minimize the transportation distances. Depending on the available means of transportation, its costs can outweigh potential economies of scale benefits at distances as small as 100 miles.

Small scale production mines and processing plants should be set up to complement those large scale ones which are being installed in most of the DCs. The idea proceeds from the broader concept of small scale industry. The Athens UNIDO Symposium outlined the

problems and promises of the small scale industry as well as the government role in its development. The objectives pursued by DC governments in promoting the small scale industry fall in two categories: the economic ones and the social ones (UNIDO$_b$ 1969).

a) Economic Objectives of Promoting Small Scale Industry

- Industry Decentralization

Entrepreneurs are naturally inclined to locate their industrial facilities in urban areas for two reasons. First, even though infrastructure may be judged limited in absolute terms, it is the most available in urban areas.

Second, for most industries, urban areas represent both a market for the products and a source of labor and most of the financial institutions are located there. Therefore, small-scale industry may be the only one suited to the geographically scattered market of rural commodities and their limited infrastructure. Also, this industry dispersal alleviates the burden on the urban areas infrastructure and their utilities facilities.

- Industry Diversification Through Backward Linkages

In some situations, a limited market may exist for the supply of parts and components to a large-scale industry and, if economically feasible, the small scale factory is the only alternative to imports.

- Utilization of Resources

Small enterprises are specially suited to process those raw materials which are not available in enough quantity to justify the construction of a large plant. This is the objective the most relevant to the mining case.

b) Social Objectives of Promoting Small-Scale Industry

- Transformation of Traditional Industry

In those areas where an industry tradition exists, the introduction of a competing modern technology often renders those traditional industries obsolete and uneconomic. Small- scale developmentprograms can bring positive solutions to the problems of those crafts technically displaced by the more efficient modern technology. Emphasis should be placed on the word positive since there would be no justification for extending the life of moribund crafts through subsidization. Here the objective would be to identify those skills which can be adapted and transformed in

modern manufacturing activities. A successful illustration is the case of village potters in India (Garg 1976). Of the 3 million village potters existing in India in 1901, only about 1.2 million were left in 1971 and half of them were only part time employed. The red color unglazed product of the traditional pottery were used for cooking, eating, fetching water, storage, and structural purposes. These products were driven out of the market by the whiteware pottery, metal recipients, and concrete products in the relevant markets. Small scale demonstration plants for the production of whiteware were set up in 4 places in the state of Uttar Pradesh (Kurja, Chinhat, Gaura, and Phoolpur). In the first place, craftsmen bought the raw material from the demonstration plant, shaped it at their houses and brought it back to the factory for firing. Later on they were encouraged to build their own kilns and be independent of the demonstration plant. It was reported that U.S.$1.9 million (of 1975) worth of whiteware products were manufactured and employment for 10,000 people had been created by the program which was still expanding.

- Employment generation

Very often, small-scale industries tend to be more

labor intensive than larger industries and employment per output tend to be higher also. However, in pursuing employment generation, one should not forget to ensure that the small-scale enterprise competitiveness with the larger scale one is preserved since that is the guarantee of perennialty of the employment generated.

- Stimulation of Local Entrepreneurship

The small enterprise is the best springboard for entrepreneurship in larger ones and mismanagement consequences are smaller in absolute terms.

As far as minerals are concerned, the topic was recently highlighted by the First International Conference on the Future of Small Scale Mining organized by the United Nations Institute for Training and Research, and held in Mexico in 1978. Even though most of the papers presented at the conference focused on metal mining, some of the issues addressed and the recommendations which were made can be extended to the industrial minerals sector.

First the advantages associated with small scale mining were identified. They were found more or less identical to the ones outlined above on small scale industry in general. In addition, small scale mines do not lend themselves "to the creation of mining towns

which later on become ghost towns" (Barnea 1978). In most of the papers, ample room was devoted to the problem faced by the industry and the remedies that government could provide.

The main problems facing the small scale miner were identified as follows.

1) The lack of sound geological data which results in the exploitation of visible veins, high grading, and eventually waste of the reserves not mined.

2) The lack of financial resources put the small-scale mining in a situation where it cannot afford the cost of infrastructure, if the mine is located in a place where infrastructure is lacking or inadequate. Likewise, the small miner cannot afford the cost of certain production tools; very often he will settle for less efficient mining and beneficiation equipment. This is of concern not only to the miner himself but also to the DC government which is the ultimate guarantor of the conservation of natural resources. The very sad situation about the small scale mining financing position is that even when credit facilities are set up, the small scale miner will not be able to meet the minimal bank loan guarantees.

Because of its inherent structural weakness that

the small scale mining cannot overcome by itself, it has been recommended that the government intervene in the following areas (Barnea 1978).

- Regional Exploration Program and Infrastructure

The concept of regional exploration was presented as a way of overcoming the problem of infrastructure availability to the small miner. If he cannot afford it on economical grounds, the government cannot afford it either. It was proposed then that the government engage in systematic exploration in view of discovering many small deposits which together will justify the construction of the requisite infrastructure. However, a thorough exploration technology which would be able to locate small hidden deposits without being cost prohibitive has yet to be devised. And even in the event such an exploration technology would be available, it is improbable that nature would have gracefully arranged the geographical distribution of the small deposits so that they can share a common infrastructure. But the nonarguable point is the need for an exploration as thorough as possible to which the government should commit adequate resources.

- Technical Assistance

Since it is widely acknowledged that the small

miner lacks technical and managerial skills, the government should make provisions for helping in assessing ore reserves, mine plan, process selection, and plant design. These services should be rendered at a price just covering the costs incurred by the government. It was reported that this recommendation had been already put in operation in India (Bhargava and Balagopal 1980), in Mexico (Salas 1980) and in the Philippines (Comsti and Relova 1980).

- Financial Assistance

In order to supplement the limited financial resources of the small scale miner, it was proposed that the government provide facilities to provide him with credit at less than the market interest rate. This could be accomplished through the establishment of mining banks or the creation of a mining window in the existing development banks. In order to channel the credit to the intended recipient, a legal definition of a small scale mine is mandatory. However no general agreement can be foundon a definition which could be applicable to all countries. One must take into account various factors such as the stage of industrialization, conditions of ore occurrence, and institutional factors (Meyer 1980).

According to the Peruvian Mining Law, a small

mining company is one with less than 1000 hectares in exploration or whose production is less than

- 200 metric tons-per-day for metal mining
- 400 metric tons-per-day for carboniferous minerals
- 400 cubic meters for construction materials

In India the distinctive features of small scale mining are the "absence of the use of deep blast hole drilling, heavy blasting, or heavy earth moving equipment" and a number of employees of less than 400 in open pit mines and 140 in underground mines (Barghava and Balagopal 1980).

In Mexico, the small mine is defined as any mine making less than 20 million pesos of gross income (Salas 1980). The Indian and the Peruvian definitions are more attractive in the sense that they are based on physical measurements rather than on monetary ones. With the Mexican definition, because of inflation, many of the small mines originally included in the "small mines category" will gradually reach the threshold of 20 million pesos and will lose the benefits associated with the small mine status. This is not only important for the qualification for a soft loan but also for the eligibility to the fiscal entitlements.

- Fiscal Incentives

In drafting legislation to stimulate small scale mining, taxation is one of the most important provisions, if not the most important. The taxes assessed per unit of production are especially burdening for the small miner and their substantial reduction or elimination would impact

By and large, from the discussion above, it should appear that small scale mining will generally be attractive to the private sector for high value commodities. The prospector who is seeking the gold vein outcrop or panning alluvial sand is driven by the hope of hitting the gold bonanza and becoming rich all at once. On the other end, low value commodities which do not require processing can be attractive to the small scale miner; he knows that his take home pay will be higher the higher the tonnage extracted. For products requiring relatively complex processing, especially in countries without mining tradition, the government may find itself the only party interested in and which has the capacity of bringing them in production. And that seems to be the case for the commodities this study focuses on.

With particular reference to the industrial

minerals, the government of Mexico has to be complimented for devising a policy specifically for that sector and creating an institution responsible for the implementation of that policy, the Fideicomiso Minerales No Metalicos Mexicanos (Kolteniuk 1980). Its distinctive objectives, i.e., not redundant with those already mentioned above, are

- the promotion of industries using industrial minerals in order to achieve import substitutions and boost exports, and
- conducting research on processes which will result in a greater utilization of the nonmetallic minerals.

The economic problems associated with the choice of production scale in achieving an adequate supply of cement throughout a DC are reviewed in order to illustrate the above general discussion.

4.2.3 Plant Size Considerations in Cement Production in Developing Countries

Among the construction inputs of industrial mineral origins, cement or some kind of cementing material is a necessary ingredient in virtually any type of durable construction. Cement is therefore a basic commodity for which significant reliance on imports is a serious

matter of concern to development planners in DCs. In countries where cement is essentially imported, the speed of the construction activity is dictated by the availability of foreign exchange; major projects are delayed for months resulting in large capital costs overruns which may turn into a failure a project which would have been otherwise profitable.

DCs efforts in order to increase their domestic cement production have been remarkable. The world pattern of cement production over the last decade is depicted in Table 4-2. Driven by the expanding cement consumption of the developing countries, world production increased from 567,232 thousand metric tons in 1970 to 867,720 thousand metric tons in 1980. However DCs own share of production increased at a higher rate than that experienced by the group of developed countries. Particularly outstanding was the Asian production (excluding Japan) which increased more than three times from 60,587 thousand metric tons to 190,099 thousand metric tons. South America's production more than doubled while Africa's production increased by 64 percent. In contrast, European, North American, and USSR production increased by 25 percent, 19 percent, and 31 percent respectively.

Table 4-2

Geographical Distribution of World Cement Production

(in thousands metric tons)

Year	1970	1972	1974	1976	1978	1980
Country/ Area						
World	567,232	664,246	700,539	743,948	835,995	867,720
Africa	18,012	20,844	22,883	22,973	24,956	29,593
North America	86,794	99,825	102,496	96,889	107,661	103,620
South America	22,521	26,988	32,164	36,176	41,456	48,716
Asia	117,776	147,699	165,861	201,520	256,809	278,057
Asia (without Japan)	60,587	81,366	93,177	132,808	171,927	190,099
Europe	220,892	258,662	255,315	255,982	272,205	276,631
Oceania	5,989	5,929	6,675	6,162	5,952	6,057
USSR	95,248	104,299	115,145	124,246	126,956	125,049

Source: United Nations 1983 Statistical Yearbook, 1981 edition, New York: United Nations Publication, p. 689.
Japan's production derived from US Bureau of Mines, Mineral Yearbook, issues from 1970 to 1982, Washington D.C.: G.P.O.

There was a lot of questioning on whether the current trend towards higher and higher kiln capacity was suitable to the DCs needs (Spence 1978). Although there are other points of comparison, the query arose essentially because of the transportation distance. Because of cement level of demand and its geographical distribution in DCs, any large scale plant must serve a very large geographical region. For instance in 1978, India, a country of about 3.2 million square kilometers, was served by 53 plants; about the same number as the United Kingdom with about 230,000 square kilometers. Sub-Saharan Africa (excluding South Africa), an area over 16 million square kilometers wasserved by 25 plants (Spence 1978). There is no doubt then that transportation costs represent a major portion of the price users pay for cement in DCs.

Figure 4-3 represents a dramatic illustration of this regrettable situation in Sudan, Botswana, and Honduras (Parry 1978); at Malakil in Sudan, delivered price of cement is about 3.5 times the plant F.O.B. price. The problem is actually aggravated by the lack of adequate transportation facilities: bad roads cause the haulage trucks to wear off quicker and contribute to higher transportation costs because of the need for

higher truck amortization.

Additional advantages credited to the small scale plants are as follows (Spence 1978).

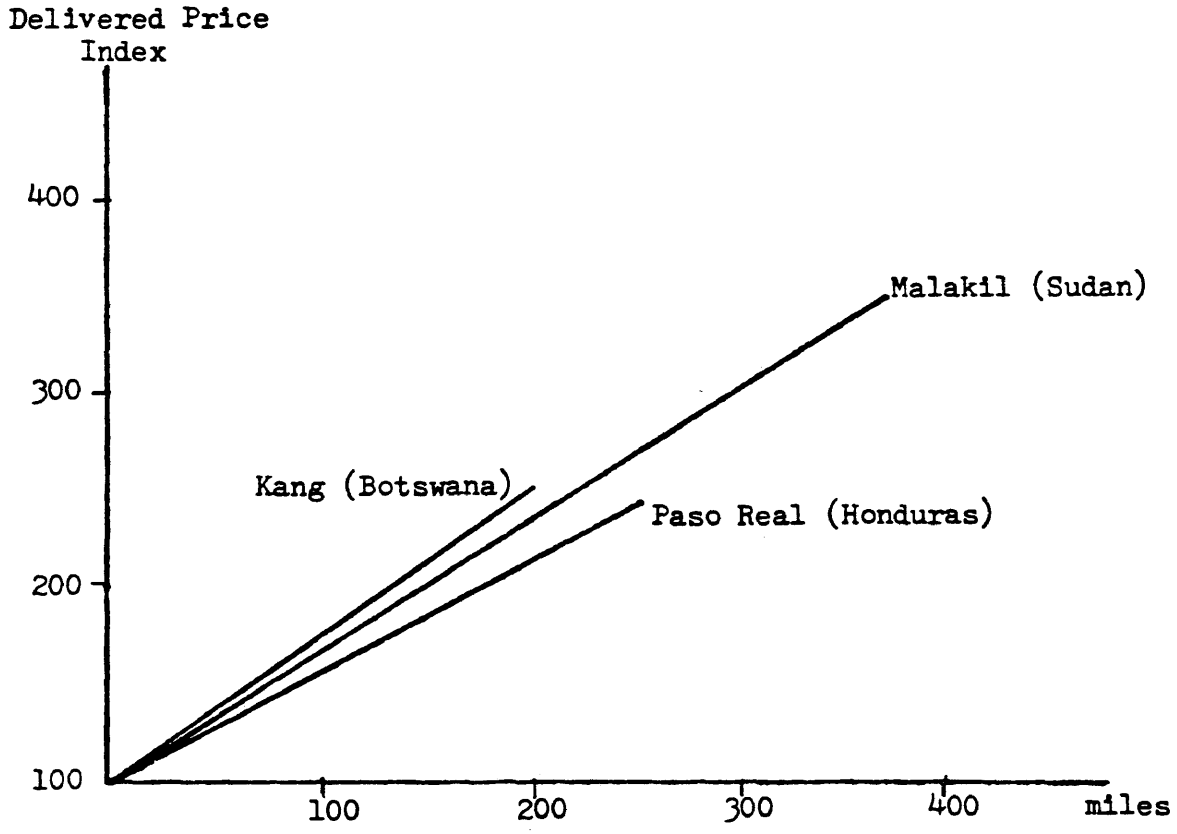
- They can be erected and brought on stream quickly
- They make only a small localized additional burden on the existing infrastructure
- The required raw materials reserve base is much smaller than for larger plants
- They could be manufactured locally, at least in the most industrialized DCs

Throughout the world, most of cement is produced in large plants equipped with rotary kilns. The disadvantages of large plants are essentially the opposite of those small scale advantages outlined above. On the other hand, however, large plants exhibit increasing returns to scale both in fixed costs and variable costs. In cement plants, the major equipment are vessel types viz. the kiln itself, the grinding ball mill or the storage silos. When one wants to increase the capacity of such plants, the volume, and hence the production capacity increase proportionally to the cube of the linear dimension while the surface will increase at the square of the linear dimension. Since the thickness of the vessel will remain

Figure 4-3

Examples of Transportation Distance Effects

on Price of Delivered Cement



Works Warehouse at: Kosti (Sudan)
Lobatse (Botswana)
San Pedro Sula (Honduras)

Source: Parry, J.P.M. 1978 "Building Materials and Components," paper presented at the International Forum on Appropriate Technology, New Delhi/Anand, 20-30 November, p.16

almost constant, the volume of the material used to build the vessel, and its cost also, will vary according to the surface. This is the theoretical fact underlying the empirical six tenths rule used in estimating the capital costs of a plant of known capacity, when the capital costs of a similar plant of a different size are known. In addition to the decline in capital costs per unit of output when plant capacity is increased, fuel consumption per unit of output is also expected to decrease for the same reason. As a matter of fact, heat losses occur through the surface; then the kiln thermal efficiency will improve with increases in capacity resulting in lower specific energy consumption.

With such decisive factors acting in favor of the large scale production apparently there is no argument for going to lower scales of production. However at small scale, it becomes possible to build the vertical shaft kiln which has a much lower specific energy consumption than the rotary kiln as shown by Table 4-3. Earlier portland cement kilns were bottle shaped vertical shaft of a batch type of operation. They could not be scaled up because their construction would have been problematic, and the homogeneity of the product was not always satisfactory. It was reported that vertical

Table 4-3

Average Specific Energy Consumption (Fossil Fuel)

by European Cement Industry

Process	Kcal/Kg cement
Wet (Long kiln)	1300
Dry (Long kiln)	860
Semidry (Great preheater, Lepol type)	850
Dry (Suspension preheater)	790
Shaft kiln	750

Source: Spence, R.J.S. 1978 "Appropriate Technologies for Small-Scale Production of Cement and Cementitious Materials." Paper presented at the International Forum on Appropriate Technology, New Delhi/Anand, 20-30 November, p. 11.

shaft kiln plants accounted for about 5 percent of the world production in 1978 (Spence 1978). Because of its low specific energy consumption, there have been numerous attempts to adapt and revive the shaft kiln technology both in the DCs and the developed countries. In India, designs for 2, 30 and 100 metric tons per day (mtpd) were developed; pilot plants for 2 and 30 mtpd were installed. The product was apparently satisfactory and the economics were comparable with those of the larger rotary plants being installed in India at that time (Spence 1978). In West Germany, Karl Beckenbach developed an annular shaft kiln in 1962, and since then 160 units have been reported operational mainly in Europe and in Japan (Cohen and Greef 1982). Its ability to burn pulverized coal is making it acceptable to U.S. lime producers. Comparative fuel consumptions for various kilns shows that the annular shaft kiln has the lowest specific energy consumption when calcining high grade limestone as shown in Table 4-4 (Cohen and Greef). The ranking would be expected to remain the same when producing clinker.

The average size of the cement plants recently built, in construction or planned in DCs is rather large; for instance it was about 1,650 mtpd in India,

Table 4-4

Range of Specific Energy Requirements for Lime Calcinations for Various Systems

	Approximate Feed Size	Approximate Fuel Consumption (10^6 Btu/st LHV)
Long Rotary Kiln** (with no heat-exchanging internals)	2" × 0	7.5-9.0
Rotary Kiln (with heat-exchanging internals)	2" × 3/16"	5.5-7.0
Rotary Kilns with Stone Preheater	2" × 3/8"	4.5-5.5
Vertical Shaft Kiln (Mixed-Feed System)	8" × 1/2"	3.6-4.3
Annular Shaft Kiln	8" × 7/8"	3.1-3.4
Double Inclined Shaft Kiln	1-1/2" × 3/8"	3.6-4.1
Flash Calciner	−20 mesh	4.2-5.0
Fluidized Bed	4 × 65 mesh	4.2-5.0

*All equipment listed here are for calcination of dry high-grade limestone (95%-98% $CaCO_3$). Fuller also offers rotary and fluidized-bed equipment for lime sludge, a wet feed with a size of 100% minus 325 mesh.

**When lower-sized material is not screened out in advance, most −1mm fraction is lost in exhaust system.

Source: Cohen, S.M. and Greef, E.B. 1982 "Coal Firing Capability May Lead to Rebirth of Shaft Kiln Technology," Pit and Quarry, May, pp. 75-78.

2,250 mtpd in Brazil, 3,040 mtpd in Indonesia, and 3,480 mtpd in Saudi Arabia (Levine 1983). There are two main reasons which hinder the development of small scale cement plants (about 200 mtpd or less): the growing urbanization and the cement price control by governments. Since cement is considered a basic commodity, many governments set the price which will be valid all over the country in fairness for remote areas. For instance, in India there is a freight equalization which amounts to 15 percent of the delivered price to users (Spence 1978), and in Indonesia, price is also reported controlled by the government (Roeslan 1980). Since the transportation costs were the major reason for developing the small scale production, a price regulation throughout the country removes that advantage. The growing urbanization in the DCs tends to concentrate the demand for cement in urban areas. This tendency is reinforced by the fact that per capita demand for cement is higher in urban areas than in rural ones. Not only the urban population needs more common infrastructure but also the dwellings are most cement intensive.

Whether small scale cement production will play a significant role in the overall production will be

largely determined by political decisions. In China where the number of small plants (less than 100 mtpd) increased from 200 in 1965 to 2,800 in 1975, such a development was believed to be the result of a political choice rather than an economic one. Indeed this was attributed to the ideology of rural community self-sufficiency prevailing in China at that time. Large plants have been reported built in this country in recent years (Levine 1983). Likewise, in Indonesia the measures advocated for increasing cement production comprise the construction of new plants of 500,000 mtpy minimum capacity and the setting up of small scale cement plants in those remote areas which are beyond the distribution areas of larger plants.

This seems to be the most reasonable approach. Where adequate reserves are available and sufficiently large demand exists, large plants should be built to take advantage of the economies of scale; however, appropriate measures should be taken to bring into production the smaller deposits which could result in overall transportation costs savings.

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

The construction sector plays a critical role in the national economy of any country. Construction raw materials of industrial minerals origin represent a major component of the overall raw materials requirements. It is the responsibility of the governments to ensure that those raw materials are available and as cheap as possible. DCs efforts to increase the local production of these materials have been both extensive and successful. However, in order to bring further development of this sector, the DCs governments should consider the measures proposed below.

- A government institution should be set up in order to promote the development of industries using the available raw materials. The institution should maintain a team of competent geologists who will work in close collaboration with the national geological survey in order to provide a sound data base of the raw materials occurrences. It should be provided with adequate research facilities. Its technical objectives would be:

a) the study of the local raw materials behavior

b) the development of processes adapted to the local conditions and raw materials

c) the establishment of standards; sometimes they are unnecessarily too stringent for the end use of the product

Upon request, the institution would prepare the necessary feasibility reports to secure the soft term credits discussed below. It would also act as an advisory body to the government for properties the government wants to exploit on its own account.

- Credit facilities should be established, if not already available, which will provide loans at concessionary terms to potential developers.

- There should be no price regulation throughout the country. Such a policy is detrimental to the development of small deposits located in remote areas and may result in shortages in areas not close to the production plants. If the price equalization is maintained, however, the government should be prepared to bring in production on its own those deposits rendered unattractive by the policy. This will lower the transportation premium users closer to production plants pay in solidarity with the more remote ones.

- Special attention should be given to the pro-

motion of small-scale production of industrial minerals building in rural areas. In some countries, special legislation has been enacted favoring in small-scale mining. It is suggested that every DC enact this kind of legislation covering small-scale production of industrial minerals for the construction sector. As a measure of encouragement, small-scale enterprises in this field should pay only profit-based taxes and should be granted a waiver of per unit taxes.

5.2 Suggestions for Further Research

Any creative research in the field of industrial minerals must start by breaking it down in more homogeneous components and possibly down to the commodity level. The criteria used in this disaggregation will depend on the particular research aim but should not be limited to the end use criterion.

The design of a research program must take into consideration the lack of international prices for most of the industrial minerals. In order to obtain specific results, the geographical scope of research should be restricted to the price validity areas.

This particular study focused on construction materials because a healthy construction sector is vital

to any growing economy, and the necessary raw materials are found almost everywhere. Besides construction, however, there are other important sectors in the economy in which industrial minerals play a key role. Among these minerals, raw materials for the fertilizer and the chemical industries are the most acknowledged. Further research efforts should be channeled essentially towards the construction, fertilizer, and chemical industries at national or regional levels.

Practically

Practically, future work should be formulated as case studies. With respect to the construction sector, cement has been publicized more than has glass and ceramics. The two last commodities have a market beyond the construction sector. As a typical case study, it is suggested that the glass situation be investigated in a particular DC. As part of the "terms of reference" for this assignment, it will be necessary to analyze the pattern of glass consumption over a recent period, perhaps the last ten years. Both the composition and the geographical distribution of glass consumption will have to be scrutinized in order to identify the glass end user sectors in the economy and their location within the country. This will enable the investigator to make reasonably accurate predictions of future consumption.

In addition to this glass demand study, sand of adequate quality and other raw materials sources will have to be identified. Production facilities sites will then be determined according to the given constraints on raw materials and demand locations. Potential supply from foreign sources, specially neighboring countries, will have to be taken into account. Whether the creation of a glass research institute is justified will depend upon the diversity and the expected growth of the glass consumption and will have to be determined for the particular country.

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APPENDIX 1

Ratios of Construction Output Value to the Gross Domestic Product and the Gross Domestic Investment

Country	(1) Per capita GNP 1977	(2) GDP/$ 1977 (million)	(3) GD Invest. (million US$)	(4) Const. GDP (million US$)	Ratio (4) (3)	Ratio (4) (2)
Algeria	1140	19416.31	9594.79	2604.92	27.15	13.42
Argentina	1870	50872.00	9732.63	1719.73	17.67	3.38
Bangladesh	80	6160.66	606.26	238.77	39.38	3.88
Barbados	1770	437.54	96.06	24.11	25.10	5.51
Belize	750	102.35	31.45	6.30	20.03	6.16
Benin	210	583.71	118.04	21.17	17.93	3.63
Bolivia	480	3426.60	758.85	169.20	22.30	4.94
Botswana	540	380.55	143.15	24.86	17.37	6.53
Brasil	1410	166,344.43	36,473.29	7698.64	21.11	4.63
Burma	140	4,229.54	595.35	43.29	7.27	1.02
Burundi	130	290.19	33.47	28.23	84.34	9.73
Cameroon	420	2,712.08	589.23	165.47	28.08	6.10
Central African R.	240	435.14	98.10	22.39	22.82	5.15
Chad	130	532.42	88.33	16.28	18.43	3.06
Chile	1250	14,918.84	1,339.13	293.37	21.91	1.97
Colombia	760	19,378.65	3,973.26	747.49	18.81	3.86
Congo	500	739.61	133.51	57.35	42.96	7.75
Costa Rica	1390	3,065.65	764.18	170.60	22.32	5.56
Cyprus	1830	1,101.72	254.41	62.99	24.76	5.72
Dominican Rep.	840	4,466.60	1,008.50	297.70	29.52	6.67
Ecuador	820	6,152.44	1,772.00	386.84	21.83	6.29
Egypt, Arab R. of	340	12,822.92	3,435.31	483.87	14.09	3.77
El Salvador	590	2,841.4	634.96	115.44	18.18	4.06
Ethiopia	110	3,297.73	292.71	115.31	39.39	3.50
Fiji	1330	771.10	163.25	29.15	17.86	3.78
Gabon	3190	2,767.94	1,876.50	417.27	22.24	15.07
Greece	2950	26,239.13	7,173.91	1872.28	26.10	7.14

APPENDIX 1 (continued)

Country	(1) Per capita GNP 1977	(2) GDP/$ 1977 (million)	(3) GD Invest. (million US$)	(4) Const. GDP (million US$)	Ratio (4) (3)	Ratio (4) (2)
Guinea	200	1,075.12	217.86	156.29	71.74	14.54
Guyana	520	438.04	123.53	30.16	24.42	6.89
Honduras	420	1,521.50	334.00	67.00	20.06	4.40
Hong Kong	2620	11,762.33	2,769.84	455.38	16.44	3.87
India	160	101,740.04	21,651.29	5371.95	24.81	5.28
Indonesia	320	45,896.39	8,667.47	2197.59	25.35	4.79
Israel	3760	14,703.32	3,277.75	1152.50	35.16	7.84
Ivory Coast	770	6,441.57	1,758.86	464.85	26.43	7.22
Jamaica	1060	3,262.38	343.67	191.75	55.79	5.88
Jordan	940	1,496.05	769.60	82.07	10.66	5.49
Kenya	290	4,428.95	937.65	188.04	20.05	4.25
Korea Rep. of	980	34,614.88	9,598.14	2200.83	22.93	6.36
Lesotho	250	203.34	60.76	15.07	24.80	7.41
Liberia	410	861.20	214.70	43.90	20.45	5.10
Madagascar	230	1,803.42	282.87	65.53	23.17	3.63
Malawi	150	852.88	179.16	53.33	29.77	6.25
Malaysia	970	13,109.71	3,052.01	460.79	15.10	3.51
Mali	120	696.26	102.58	34.19	33.33	4.91
Mauritania	270	4,444.14	230.08	37.21	16.17	8.38
Mexico	1160	74,251.29	15,257.84	4390.66	28.78	5.91
Morocco	610	10,397.51	3,315.12	927.16	27.97	8.92
Nepal	110	1,387.52	137.28	23.12	16.84	1.67
Nicaragua	870	2,217.90	543.55	102.70	18.89	4.63
Niger	190	911.79	212.89	34.60	16.25	3.79
Nigeria	510	40,148.14	12,504.66	2340.06	18.71	5.83
Pakistan	200	14,788.14	2,786.93	742.72	26.65	5.02
Panama	1200	2,254.40	490.20	110.10	22.46	4.88
Papua New Guinea	510	1,515.76	284.99	120.55	42.30	7.95
Paraguay	750	2,092.16	516.44	83.81	16.23	4.01
Philippines	460	20,797.08	5,986.77	1533.14	25.61	7.37
Portugal	1840	16,255.19	4,125.19	945.74	22.93	5.82
Zimbabwe (Rhodesia)	460	3,023.11	573.40	135.32	23.60	4.48
Rwanda	160	761.33	113.10	31.63	27.97	4.15
Senegal	380	1,931.05	326.86	97.28	29.76	5.04

APPENDIX 1 (continued)

Country	(1) Per capita GNP 1977	(2) GDP/$ 1977 (million)	(3) GD Invest. (million US$)	(4) Const. GDP (million US$)	Ratio (4) (3)	Ratio (4) (2)
Sierra Leone	200	643.37	85.51	19.28	22.55	3.00
Singapore	2820	6,549.41	2,179.99	492.21	22.58	7.52
Somalia	120	431.02	152.50	26.81	17.58	6.22
Spain	3260	115,614.67	26,324.59	7681.18	29.18	6.64
Sri-Lanka	160	2,351.72	387.79	84.59	21.81	3.60
Sudan	330	6,008.62	916.67	182.18	19.87	3.03
Syrian Arab. Rep.	860	6,615.70	2,600.00	455.44	17.52	6.88
Taiwan	1180	19,847.37	4,936.84	1000.00	20.26	5.04
Tanzania	210	3,416.73	585.21	91.73	15.67	2.68
Thailand	430	18,779.41	4,926.47	990.19	20.10	5.27
Togo	280	668.78	214.92	33.38	15.53	4.99
Trinidad and Tobago	2620	2,968.04	746.13	205.50	27.54	6.92
Tunisia	840	4,981.35	1,503.50	435.90	28.99	8.75
Turkey	1110	47,789.14	12,198.65	2394.17	19.63	5.01
Upper Volta	140	683.84	171.78	25.64	14.93	3.75
Uruguay	1450	4,194.11	598.34	148.00	24.74	3.53
Venezuela	2630	35,600.19	14,113.23	2490.45	17.65	7.00
Yougos-lavia	2100	44,130.51	14,602.69	4786.12	32.78	10.85
Zaire	210	4,955.78	920.42	232.21	25.23	4.69
Zambia	460	2,435.11	630.29	195.18	30.97	8.02
Libyan Arab Rep.	6520	19,425.68	4,729.73	2033.78	43.00	10.47
Oman	2510	2,531.88	657.39	256.23	38.98	10.12
Saudi Arabia	7230	56,869.97	16,392.92	7140.79	43.56	12.56
Austria	6450	47,951.84	14,067.89	4241.54	30.51	8.85
Belgium	8280	79,205.38	17,030.78	5998.72	35.22	7.57
Canada	8350	200,337.72	45,667.92	12766.70	27.96	6.37
Finland	6190	30,170.51	8,182.92	2477.04	30.27	8.21
France	7500	380,683.90	89,497.25	28536.54	25.54	7.50
Germany Fed. Rep. of	8620	516,372.25	112,624	37139.16	32.98	7.19

APPENDIX 1 (continued)

Country	(1) Per capita GNP 1977	(2) GDP/$ 1977 (million)	(3) GD Invest. (million US$)	(4) Const. GDP (million US$)	Ratio (4)/(3)	Ratio (4)/(2)
Italy	3530	196,044.83	41,459	14652.48	35.34	7.47
Japan	6510	691,139.99	212,037	55184.94	26.03	7.98
Nether-lands	7710	102,601.18	23,202	5868.34	25.29	5.72
South Africa	1400	39,838.90	9,795	1727.34	17.63	4.34
Sweden	9340	78,276.72	15,445	5324.03	34.47	6.80
United Kingdom	4540	244,884.62	46,708	15429.58	33.03	6.30
United States	8750	1878,800.00	346,900	84900.00	24.47	4.52

Source: World Bank 1980 World Tables, second edition, Baltimore: The Johns Hopkins University Press

APPENDIX 2

Percentage Share of Construction Materials in the Value of Industrial Minerals Products Imports

Country	Percentage	Year
Afghanistan	28.05	1977
Algeria	39.51	1980
Antigua and Barbuda	26.60	1978
Argentina	36.97	1980
Australia	22.73	1980
Austria	29.65	1981
Bahrain	64.08	1980
Bangladesh	85.15	1979
Barbados	25.04	1978
Belgium - Luxembourg	5.29	1981
Belize	42.33	1978
Benin	79.81	1974
Bermuda	17.11	1980
Bolivia	40.11	1978
Brazil	47.80	1981
British Virgin Islands	69.59	1976
Brunei	79.59	1980
Burma	9.23	1977
Burundi	48.45	1979
Cape Verde	100.00	1978
Central African Rep.	70.13	1980
Chad	64.24	1975
Chile	28.56	1978
Congo	58.42	1979
Costa Rica	14.88	1980
Cyprus	35.01	1981
Czechoslovakia	2.80	1980
Djibouti	46.03	1979
Dominica	39.42	1978
Dominican Rep.	32.01	1981
Ecuador	62.48	1980
Egypt	77.86	1981
Ethiopia	41.12	1980
Faeroe Islands	44.40	1981
Fiji	13.18	1980

APPENDIX 2 (continued)

Percentage Share of Construction Materials in the Value of Industrial Minerals Products Imports

Country	Percentage	Year
France	24.98	1981
French Guyana	75.58	1981
French Polynesia	74.55	1981
Gabon	72.72	1977
Gambia	67.66	1977
German Dem. Rep.	20.87	1981
Germany, F. Rep.of	22.27	1981
Ghana	72.30	1978
Greece	27.62	1981
Greenland	38.76	1981
Guadeloupe	70.61	1981
Guatemala	55.94	1979
Guinea Bissau	61.46	1977
Guyana	41.27	1979
Haiti	13.88	1978
Hong Kong	15.71	1981
India	14.55	1979
Indonesia	53.29	1981
Iran	74.93	1977
Iraq	50.81	1976
Irlande	13.06	1981
Israel	4.91	1981
Ivory Coast	72.08	1979
Jordan	66.31	1980
Kuwait	79.14	1980
Laos	70.33	1974
Lebanon	58.16	1977
Liberia	67.64	1981
LibyanJamahiriya	73.40	1980
Macau	43.27	1980
Madagascar	54.72	1980
Malawi	57.66	1980
Malaysia	32.16	1980
Mali	85.10	1977
Malta	43.36	1980
Martinique	68.41	1981
Mauritius	52.25	1978
Montserrat	80.83	1978
Morocco	13.79	1980

APPENDIX 2 (continued)

Percentage Share of Construction Materials in the Value of Industrial Minerals Products Imports

Country	Percentage	Year
Nepal	95.54	1977
Netherlands	21.82	1981
New Caledonia	71.37	1981
Niger	32.27	1976
Nigeria	70.64	1979
Oman	91.97	1981
Pakistan	75.12	1981
Papua New Guinea	58.71	1976
Paraguay	39.39	1979
Peru	19.35	1980
Qatar	90.26	1980
Reunion	67.64	1981
Rwanda	83.32	1976
Saint Lucia	36.01	1980
Saint Pierre et Miquelon	69.40	1981
St. Vincent Grenadines	65.96	1976
Samoa	62.18	1979
Saudi Arabia	69.66	1981
Senegal	35.23	1981
Seychelles	56.11	1980
Sierra Leone	80.49	1976
Singapore	27.20	1981
Solomon Islands	54.67	1977
Somalia	77.83	1979
Sri Lanka	30.68	1981
Sudan	47.47	1980
Suriname	35.59	1974
Switzerland	6.04	1981
Syrian Arab Rep.	83.21	1979
Thailand	46.28	1980
Togo	58.73	1979
Tonga	64.38	1980
Trinidad and Tobago	45.07	1981
Tunisia	44.93	1980
Turkey	46.61	1981
Uganda	19.31	1976

APPENDIX 2 (continued)

Percentage Share of Construction Materials in the Value of Industrial Minerals Products Imports

Country	Percentage	Year
United Arab Emirats	56.70	1979
Un. Rep. of Cameroon	67.57	1980
Un. Rep. of Tanzania	62.94	1980
U.S. Virgin Islands	47.68	1978
Upper Volta	85.18	1980
Uruguay	44.68	1980
Venezuela	47.09	1980
Yemen	73.64	1980
Yougoslavia	22.08	1981
Zaire	25.61	1978
Zambia	52.21	1978
Zimbabwe	55.74	1979

Source: United Nations 1983 Yearbook of International Trade Statistics, 1981 Edition, New York: United Nations Publication, Volume 1.