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THE ECONOMICS OF COLOMBIAN COAL RESOURCES: PROBLEMS AND PERSPECTIVES

by

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ABSTRACT

The purpose of this study is to determine the feasibility for Colombia to share in the international coal trade, as a modest but well organized exporter. To reach this objective a detailed analysis of the world market pattern is made to determine present trends, volume of coal trade, and future potential. Special emphasis is given to the Latin American market, taking into account the trade privileges provided by the LAFTA (Latin American Free Trade Association) and Andean Pact. Forecasts for Latin American coal and coke imports, and Colombian output for 1980 are made using a multiple regression model. The results of this model have been modified, and low and high estimates are provided.

The Colombian coal industry is composed, on the one hand, of a relatively well organized and modernized sector and, on the other hand, a more primitive one involving medium and small-size operations. This latter sector accounts for about 40 to 50 percent of total output. The relevant parameters influencing the development of Colombian coal mining are studied. The possible volume of Colombian coal to move in 1980 through the Atlantic and Pacific oceans, and

the coalfields best situated to meet that potential demand are determined. Finally, some courses of action are identified in order to build a strategy that will produce a firm growth of Colombian coal production aimed toward foreign markets. In line with the latest Colombian regulations on foreign investment, the joint international venture seems to be the best form or organization to reach this export goal.

CONTENTS

ILLUSTRATIONS

TABLES

TABLES--Continued

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INTRODUCTION

The contribution of the mining industry to gross domestic product of Colombia, including petroleum, was 0.6 percent in 1968 and is, in general, about 1 percent. Colombia has also imported in the past many minerals and mineral products. These factors indicate that Colombia is not a mining country. However, it is perhaps the most important producer in the world of emeralds, the leading producer of gold and platinum in South America, and it has the largest coal resources in Latin America.

Although detailed evaluations do not exist, there are good indications about the availability of precious metals and coal in exploitable, economic amounts. This statement is based on the following factors: The annual output for precious metals and coal reached 25.3 percent and 8.1 percent, respectively, of the gross value of the mining industry in 1969 including petroleum; the exploitation of gold dates back to the period before the arrival of the Spanish Conquerors; the physical output of coal was 3.16 percent of the whole

mining industry in 1969; and the results of regional geologic studies were quite favorable.

There is no doubt that, in order to solve its multiple problems, Colombia needs more foreign exchange. At present, the main source of such exchange is a single commodity--coffee. The development of mineral commodities provides the most immediate opportunity for obtaining foreign currency. The known mineral commodities should logically have preference in the official policy of encouragement of the mining sector aimed toward international markets.

Thus, coal was selected for this study in view of its growing importance all over the world. Coal is important not only as a source of energy but also as a metallurgical agent in coke production, mainly for steel making, and in the more distant future, as a raw material for a carbo-chemical industry. During the last decade the international coal trade has grown dramatically, and the world has witnessed the rapid rise of new exporting countries in a few years: Australia, Canada, and South Africa. In relation to international trade, the bulk carrier shipments of coal have increased from about 10 million short tons in 1960 to about 55 million short tons in 1970 (Oyler and Rathburn, 1972, p. 79).

A feasibility study for a particular deposit, well situated in relation to international markets, would be very important for achieving export goals in a short period; but the

lack of reliable and sound data prevented the consideration of such an analysis. Thus, this paper will be devoted to a more general study concerning the development and modernization of the Colombian coal industry.

On this basis, the study starts by presenting a general information about the coal: the concepts of rank, petrology, geological origin, and reserves are explained in Chapter 2.

The next chapter is a market study covering the latest available information. A detailed analysis of the market is needed, being a primary prerequisite for development of a coal mining industry. The analysis starts with world supply and demand, considering the main exporting and consuming areas, and their potential. A separated section is dedicated to the LAFTA and Andean trade agreements which have been formed to encourage the trade among member countries, including Colombia.

The study then continues with the analysis of the present pattern of the Colombian coal industry: location of coalfields, market structure and trend, and relevant problems affecting the coal industry. The real trade prospects of Colombia in the domestic and foreign markets are presented in the subsequent chapter, and the more favorable coalfields for future development in order to meet such potential demand are pointed out. Finally in the last chapter some key points in building a strategy for the development of the sector are pointed out.

As the successful development of the Colombian coal industry in the final analysis depends on political factors, this study is not based on strict models. Rather, its objective is to provide a general diagnosis of the problem together with some suggested courses of action for decision-makers so that past failures will not be repeated. The most important conclusions are that the dynamic growth of the Colombian coal industry in the near future will depend on its capability to enter into international trade and that the success of the industry in the international market will depend on capital-intensive methods against labor-intensive ones.

CHARACTERISTICS OF COAL DEPOSITS

Coal is a material from vegetal origin with widespread occurrence throughout the world. It is a bulk commodity highly affected by transportation costs, and is hetereogeneous in physical properties to a greater degree than most industrial minerals and rocks. Physical and chemical properties influence its end uses so it is important to get a general knowledge about these properties.

Geology

General. Coal, considered often as a mineral for trade purposes and in mining legislation, is a sedimentary rock or, better, a group of rocks with a common organic origin. Buried vegetal matter underwent modifications by biological, chemical, and physical processes through geological periods that determined its "rank", an important parameter in all the coal classification systems. The transformation of plants into coal begins with peat as the lowest rank and ends with anthracite as the highest. This is the phenomenon called "coalification" or "carbonification". The relevant members of the rank series,

after peat, are lignite, sub-bituminous coal, bituminous, and anthracite. A higher rank means ordinarily a darker color, greater hardness and compactness, different fracture, less moisture and volatile matter, and higher calorific value and fixed carbon.

A second important factor in evaluating coal and its utilization is its petrological composition. Macerals is the name given to the coal components, just as minerals are the components of rocks. There are three main maceral groups that form the basis of coal potrology: vitrinite, exinite and inertinite. Vitrinites form the brilliant black bands of coal and are the most important component of coal used in metallurgy and chemistry. They produce gas and tar in the coking process and in low-temperature carbonization (Williamson, 1967, p. 222). Inertinites are chemically inert and do not agglomerate, restricting the coking ability of the coal.

Using macerals as a basis, specialists classify four macroscopic components (lithotypes): vitrain, clarain, fusain, and durain. Vitrain and fusain are formed by individual macerals, vitrinite and inertinite respectively. The rest of the lithotypes are formed by the three macerals groups, with vitrinite dominant in clarain and inertinite in durain. Lithotypes are the basis for the classification

by types: bright coal - predominately vitrain and clarain, semi-splint - predominately clarain with some vitrain and durain, splint - predominately durain with lesser amounts of vitrain than splint. Small quantities of fusain are present in all the types (Yancey and others, 1968, p. 1-17). The types are ordered in decreasing scale of coking properties, although this is not necessarily an exact rule. The previous petrological nomenclature is known as the Stopes-Heerlen (S-H) system. Another important system was developed by Reinhardt Thiessen and is known as the Thiessen-Bureau of Mines (TBM) system.

Coal petrology is relatively a young science but it can provide multiple uses, for instance in the quantitative determination of rank levels in blends of coking coals (Stach, 1967, p. 16), in the horsepower required to win coal (continuous miner system), and in breaking methods in preparation plants.

The geological age of coal seams in the world is of importance. Geologically there have been two great eras of humolith coal formation. The first one was the Paloeozoic, from the Lower Carboniferous to the Permian, that caused most of the abundant coal resources in North America and Europe. The vegetation was very different from that of the present and was formed by giant Cryptogams. The climate conditions were rainy tropical or subtropical with rather constant temperature. The second one began in the late Cretaceous

(Mesozoic era) and reached its peak in the Tertiary (Cenozoic era). The vegetation was predominately Conifers (sequoia). These coals, consisting mostly of lignites and brown coals, are commonly of lower rank than the carboniferous coals.

Colombian Coal. Colombian coal deposits are very young geologically. Coal deposits in Colombia are not carboniferous. All coals occur in Cretaceous and Tertiary formations. According to geological studies, the best deposits occur in Upper Cretaceous (Maestritchiane) and Lower Tertiary (Paleocene-Eocene). There are also coal deposits in the Middle Tertiary and Lower Cretaceous, but these seams are thin and limited in extent. Nevertheless, it is very risky to make such generalizations, given the superficial character of most of the geological studies performed in Colombia. The Middle Tertiary coals are lignites, and Lower Cretaceous anthracites.

In spite of the fact that the Colombian deposits were formed in a geological time that in other regions of the world created lignites, brown coals, and small amounts of sub-bituminous, they are higher rank - bituminous and coking bituminous coals, semi anthracites and anthracites. In Colombia it appears that bituminous coal deposits predominate. The reason for the higher ranks, according to geological theories, are greater temperatures because of intrusion bodies (magmatism) and the regional geothermal gradient,

and high pressures and folding (tectonism). There is a disagreement about the last point between the American and the European schools. The latter one takes the position that pressure does not have an influence on the chemical transformation of the coalification process, it only affects physical properties (Teichmuller and Teichmuller, 1966, p. 152, 214).

It is very probable that these young deposits, affected by local phenomena, have sharper variations of quality than those which underwent a normal coalification process. For example, in Cundinamarca and Boyaca states (Fig. 4), within the same coalfield some seams produce good metallurgical coking coal while others do not (Suarez Hoyos, 1957, p. 13). The deposits of the Paz del Rio - Sogamoso area (Boyaca) present seams varying from low-grade to medium and high-grade bituminous coal within a distance of only 40 km. (Prieto Isaza, 1954, p. 116).

Reserves

The study of coal reserves will be considered by geographical areas, going from worldwide basis to the specific study of Colombian reserves.

World. The estimates of economic world reserves is not an easy task, because of the lack of reliable data in many regions and the different ways of considering them (for example, minimum thickness of beds, maximum thickness of overburden, and economic considerations). The international authority for the collection of energy information and the main source of resource data is the World Energy Conference (W.E.C.) which collects them every six years, the last one being 1968. It has two categories for the classification of coal reserves: "measured reserves" which must occur in seams at least 30 centimeters in thickness and no more than 1200 m in depth, and "indicated and inferred reserves" with the same boundaries as the previous ones but with only approximate estimates based on geological inference (Armstrong, 1972, p. 527). This classification is similar to the one used in the U.S., the main groups of which are measured (or proven), indicated (or probable), and inferred (or possible). A most useful concept about reserves, not considered by geologists, is the one of "recoverable" reserves that takes into account economic and technical factors. These are reserves which can be won under current conditions of technology and market patterns, and under foreseeable changes in the future.

The following table shows the world reserves of anthracite and bituminous coal by regions and countries. The figures are in general from the W.E.C. survey of 1968.

TABLE 1

Anthracite and Bituminous Coal Reserves of the World

(Billions of metric tons)

Description	Measured	Indicated and Inferred	Total	Percent World Total
AFRICA	41.7	44.0	85.5	1.3
South Africa (Republic of)	36.9	35.6	72.5	1.1
Others	4.8	8.4	13.0	
NORTH AMERICA	114.8	1,049.7	1,164.5	17.4
Canada	42.6	18.4	61.0	1.0
United States	72.6	1,028.0	1,100.0	16.4
Mexico	0.2	3.3	3.5	--
Others	--	--	--	--
SOUTH AMERICA	3.9	9.8	26.2	0.4
Brazil	3.2	7.5	10.7	0.2
Chile	0.1	0.1	0.2	--
Colombia	--	--	12.5	0.2
Others	0.6	2.2	2.8	--
ASIA	20.2	110.3	1,142.6	17.0
China	--	--	1,011.0	15.1
India	12.7	93.6	106.3	1.6
Japan	0.5	0.3	0.8	--
Others	7.0	16.4	24.5	--
ASIA-EUROPE	145.3	3,977.6	4,126.9	61.4
Turkey	0.2	1.1	1.3	--
U.S.S.R	145.1	3,976.5	4,125.6	61.4
OCEANIA	3.3	13.5	16.8	0.3
Australia	3.0	13.0	16.0	0.2
Others	0.3	0.5	0.8	--
EUROPE	127.1	24.5	152.9	2.3
France	--	--	2.8	--
Germany, Fed R.	70.0	--	70.0	1.0
Netherlands	2.4	--	2.4	--
Poland	32.4	13.3	45.7	0.7
United Kingdom	12.2	3.3	15.5	0.2
Others	10.1	7.9	16.5	--
WORLD TOTAL	456.3	5,229.4	6,711.5	100.0

Source: Quoted from Armstrong (1972, p. 528).

Most of the potential coal resources of the world are concentrated in the U.S.S.R. The U.S. and China account also for appreciable percentages of the total reserves (see Table 1). Africa, Oceania, and South America have small resources but intensive exploration could increase them.

Table 2 illustrates the coking coal resources for selected countries.

TABLE 2

Estimated Coking Coal Reserves for Selected Countries
(billion metric tons)

	Coking Coal
United States	256
Canada	17
Colombia	3
Balance Western Hemisphere	3
Germany	74
United Kingdom	56
Czechoslovakia	2
Poland	22
France	4
Balance Europe	3
South Africa	19
Australia	6
Balance Africa and Australia	1
U.S.S.R.	320
China	223
India	14
Japan	4
Balance Asia	1
Grand Total	428

Source: U.S. Geological Survey and Occidental Petroleum Corporation, quoted from Beatty (1972, p. 93).

Data of tables 1 and 2 are not comparable because figures for reserves of coking coal are not shown in table 1. Estimates by different sources, even in well explored areas, can vary widely due to different criteria used in making these evaluations.

In brief, the U.S., the U.S.S.R., and Mainland China account for 75 percent of total world coking coal reserves and 80 percent of total world coal reserves (Bellano, 1971, p. 83).

Latin America. The problems of reserve estimates have been treated in detail earlier. The reserves of bituminous coal and anthracite for South America and Mexico (in billions of metric tons) as shown in table 1, are as follows: measured, 4.1; indicated and inferred, 13.1; total, 29.7. As in previous cases, different sources provide different estimates; for example, table 3 below shows a different source of reserve figures quoted by Grunwald and Musgrove (1970, p. 294):

TABLE 3

Latin American Coal Reserves Circa 1960
(million metric tons)

Country	Reserves	
	Exploitable[1]	Total
Latin America	17,000	23,000
Argentina	250	454
Brazil	1,100	1,700
Chile	1,455	3,100
Colombia	12,000	12,500
Ecuador	2	2
Mexico	1,817	4,200
Peru	400	400
Venezuela	30	342

[1]Coal in economically exploitable seams of known thickness and extent (generally not less than 30 cm thick nor more than 1200 m below the surface).

Souces: ECLA and WEC quoted from Grunwald and Musgrove (1970, p. 294).

The characteristics of Latin American reserves according to table 3, are the following: the reserves of Argentina, Ecuador, and Venezuela are predominately or exclusively of sub-bituminous coal. The reserves of Mexico and Colombia are predominately bituminous coal, estimated at 15,000 million metric tons and 40,000 million metric tons, respectively. The data for Chile exclude 29,000 million metric tons of lignite. For Peru 6,000 million metric tons of anthracite coal are estimated (Grunwald and Musgrove, 1970, p. 294).

Colombia. There is common agreement among geologists that Colombia has most of the coal resources of South America; but

the discrepancies are big when concrete data about them are considered. Generally, the figures provided are based on geological speculations. The first valuation was done in 1913 by Pereira Gamba (1913, p. 578) who estimated 27 billion of metric tons of potential reserves. Later the Servicio Geologico Nacional provided a figure of 18 million metric tons of potential reserves. Other more optimistic sources evaluated potential reserves of 40 billion metric tons and up. Table 4 summarizes the different reserve studies:

TABLE 4

Colombian Coal Reserves According to Different Specialists (million metric tons)

Description	Pereira Gamba F. 1913	Alvarado 1939	Hubach 1954	Mutis-Suescun 1958	ECLA 1958
Potential	27,000	17,000	40,000	3,300	40,000[1]
Probable	--	--	--	420	409[2]
Proved	--	--	--	75	49

[1] There are two figures in the same study: 40,000 and 3,350.

[2] There are two figures in the same study: 409 and 667.

Source: Oficina de Planeacion, Ministerio de Minas y Petroleos (1971)

Besides these data, the U.S. Geological Survey and Occidental Petroleum Corporation's Market Research Department (Bellano, 1971, p. 82) estimate 12 billion metric tons of

total reserves and 3 billion metric tons of coking coals for Colombia. The Oficina de Planeacion (Planning Office) of the Ministry of Mines and Oil provided the following estimates based on most recent geological studies: possible reserves, 4,674 million metric tons; probable reserves 520 million metric tons; and proved reserves, 175 million metric tons. The distribution of such reserves by states is as follows:

TABLE 5

Coal Resources by States
(million metric tons)

Departments	Possible	Probable	Proved
Boyaca	1,980	185	38
Antioquia	1,220	45	--
Cundinamarca	460	46	5.4
Norte de Santander	500	--	15
Guajira	212	212	110
Santander	125	20	6
Valle	47	12	0.6
Cesar	13	--	--
Caldas	80	--	--
Other	37	--	--
TOTAL	4,674	520	175

Source: Oficina de Planeacion. Ministerio de Minas y Petroleos, 1971, p. 5.

It seems that the above data are underestimated in terms of potential resources; most of the basins are not reported because of unreliable data. However, even when the most conservative figures are used, there is an adequate

basis for organizing a modest coal industry which will generate economic benefits to the country.

As mentioned earlier, the Colombian coals range through the entire scale of rank with bituminous coal predominant. It is important to point out the great variation in coal analysis, even within the same region. Table 6 shows some selected analyses. Although they cannot be taken as an average for the mentioned region, they confirm the existence of sharp variations in coal rank.

TABLE 6

Selected Analyses for Colombian Coals

Basins	Moist %	Ash %	Volatile Matter %	Fixed Carbon %	Sulfur %	Calorific Value btu/lb.	Coke %
Pubenza-Dindal	1.7	1.7-7.3	21-44.8	52-75	0.7	11900-14800	--
Tunja-Duitama	2.2-2.6	4.5-8	38-54	31-52	1.0-1.2	11600-12600	36-80
Cogua-Samaca	1.6-3.8	5.8-6.7	32-40	53-59	0.6-0.9	12600-13800	58-78
Carare (Landazuri)	1.5-2	2-6.8	9-10	32-87	0.6-0.8	14100-14800	88-89
Toledo	0.5-1.2	1.2-3.7	31-47	48-68	0.6-2.3	14100-15200	--
Rio Zulia	1.2-1.3	0.8-6.9	34-34.5	57-64	0.8	13500-14600	--
La Jagua de Ibirico[1]	2-10	1-5	32-47	48-58	0.5-1	11500-13600	--
Cerrejon	2-7	1-8	34-38	55-60	0.4-1	12700-14500	--
Cali-San Francisco	.7-1.3	4.4-28.6	36-46	35-48	0.3-4.7	11700-13500	53-60
Rio Sucio-Quinchia	2.0-4	1.8-4.3	30-42	36-59	1.2-3.0[2]	8200-11700	--
Sopetran-Amaga	3.6-11	1.2-6.2	30-48	42-59	0.4-1.2	9200-11300	--
Puri-Caseri (Bajo Cauca)[3]	9.0	5.7	35	40	0.8	10400	6
Tado	15	4.4	31	69	3.0-3.5	14100	--

Sources: Adapted from Castro Orjuela (1970)
1. Mutis Jurado (1957)
2. Reichmann (1950)
3. Sarmiento (1953)

COAL MARKETS

World Output and Trade

Coal as a primary source of energy played the most important role in the beginning and subsequent steps of development of the industrial revolution, being the motor of technical progress. In 1900, coal accounted for 65 percent of all energy consumption in the world. This amount increased to 88 percent in 1910 (Brison, 1972, p. 813). Ever since, it has been losing markets as a result of the competition of oil and natural gas. Advantages in transportation costs, handling, and production of energy per ton have been the relevant factors for this situation.

The energy crisis, a common topic in these days, could produce a new successful comeback for coal mining in the next decades. Coal reserves are abundant, specifically in those countries facing the crisis.

Table 7 shows the evolution of coal output in percentage for selected years relative to other primary energy sources:

TABLE 7

World Primary Energy Output in Percent for Selected Years

Description	1929	1950	1965	Average annual rate of change 1929-1965
Solid fuels	77.8	59.2	40.5	1.3
Liquid fuels	17.2	24.9	41.4	5.7
Natural gas	4.2	9.3	16.1	7.1
Hydroelectricity	0.8	1.6	8.0	5.8
Total	100	100	100	3.2

Source: Darmstadter and others, 1971, p. 21.

This trend is not uniform in the different areas of the world. For example, in 1963 coal represented 90 percent of the energy market in Poland, 60 percent in the USSR, and about 20 percent in the U.S. (Zielinski, 1972, p. 5). Transportation, household and commercial, and industrial uses to a lesser degree have been the most vulnerable markets whenever coal has been facing competition. The electric utilities market has been the only one where coal has made significant progress. It accounted for 9 and 29 percent of total coal output in 1929 and 1965, respectively (Darmstadter and others, 1971, p. 78). In brief, this market has been almost the only stimulus to maintain the vitality of coal industry.

In spite of the fact that coal has been at a disadvantage during these years, it maintains a second place in world mining output for a single commodity, following petroleum

output. This position does not take into account lignite output which, by itself, ranked in sixth position in 1968 (Callot, 1971, p. 18).

Table 8 shows the world output since 1960 of lignite, bituminous coal and anthracite.

TABLE 8

World Production of Coal
(thousand of short tons)

Year	Lignite	Bituminous and Anthracite	Total
1960	699,395	2,199,905	2,889,300
1961	725,384	2,010,663	2,736,047
1962	750,612	2,059,719	2,810,331
1963	783,941	2,138,939	2,992,930
1964	817,930	2,213,164	3,031,094
1965	812,785	2,265,753	3,078,538
1966	808,386	2,306,059	3,114,445
1967	792,304	2,154,382	2,996,686
1968	809,082	2,277,384	3,086,366
1969	838,245	2,350,309	3,234,654
1970	865,354	2,433,075	3,298,429
1971[P]	883,609	2,286,820[1]	3,170,429[1]

P: Preliminary

1: These figures do not include anthracite output

Source: U.S. Bur. Mines, Minerals Yearbooks, v. I-II, 1960-1970.

U.S. Bur. Mines, Coal Bituminous and Lignite in 1971. Mineral Industry Surveys.

One important aspect of the world coal output is that it comes mainly from the northern hemisphere. The southern hemisphere (South America, Africa, and Oceania) accounted for only 4.8 percent of total output in 1970. Nevertheless, South Africa and Australia are now important exporters of coal. Three countries - the U.S., the U.S.S.R., and mainland China - shared 51.8 percent of world output (19 percent for the U.S., 20.8 percent for Russia, and 12.2 percent for mainland China) during 1970. But the U.S. is by far the biggest producer of bituminous coal in the world.

United States. The energy demand has doubled in the U.S. over two decades between 1950 and 1971 (U.S. Dept. of the Interior, 1972, p. 6), but coal is not the most important primary source of energy at the present time. In 1971 coal accounted for 19 percent of total demand for primary fuels and it is estimated that in 1985 coal's share will be only 17 percent (Beall, 1972, p. 42). In 1971 the coal demand was as follows: electric utilities 59 percent, industrial 18 percent, coke 21 percent, residential and commercial 2 percent (Beall, 1972, p. 45).

In spite of record production in 1970 (612,761 M short tons), U.S. coal mining faces serious problems: those originated in the new Federal Coal Mine and Safety Act of 1969 that has caused increases in mining costs, in the State

mining laws and projected Federal laws against strip mining, and in the regulations of the Environmental Protection Agency (EPA), especially with respect to sulfur emission standards, to be met in 1975. All these measures will affect the production and use of domestic coals because about 60 percent of coal mined today will not meet the air quality standards of the EPA (Beall, 1972, p. 44).

The next table shows U.S. production, consumption, imports and exports of bituminous coal and lignite since 1960;

TABLE 9

Significant U.S. Figures for Bituminous Coal and Lignite Since 1960
(in thousand short tons)

Year	Production	Consumption	Imports	Exports
1960	415,512	380,429	260	36,491
1961	402,977	374,405	164	34,970
1962	422,149	387,744	232	38,413
1963	458,928	409,225	267	47,078
1964	486,998	431,116	293	47,969
1965	512,088	459,164	184	50,181
1966	533,881	486,266	178	49,302
1967	552,626	480,416	227	49,528
1968	545,245	498,830	224	50,637
1969	560,505	507,275	109	56,234
1970	602,432	515,619	36	70,944
1971	552,192	494,862	111	50,633

Source: U.S. Bur. Mines, Minerals Yearbook, v. I-II, 1960-1970 Coal

U.S. Bur. Mines, Coal-Bituminous and Lignite in 1971. Mineral Industry Surveys.

The annual rate of growth in output and consumption is small, following the world trend. The imports are not significant and exports exhibit irregular fluctuations. Coke production was 66,525 M short tons in 1970, with exports totaling 2,514 M short tons. Anthracite production has been declining over the years; in 1966 it reached 12,941 M short tons, and in 1970 it was 9,729 M short tons, a decrease of about 25 percent. In 1970 the anthracite exports totaled 789 M short tons.

Where does the U.S. coal export go? Statistics show that the exports, predominately bituminous coals, go to all the continents. Table 10 illustrates the export figures by main regions since 1966.

TABLE 10

Coal Exports from U.S. to Main Regions, 1966-1971
(in thousand short tons)

Year	Canada and Mexico	South America	West Europe	Asia	Others
1966	15,882	2,613	22,230	7,799	783
1967	15,370	2,562	18,753	12,220	623
1968	16,822	2,569	14,783	15,839	624
1969	16,905	2,869	14,788	21,368	314
1970	18,846	2,920	20,858	27,649	671
1971	17,856	2,673	16,141	19,705	273

Source: U.S. Bur. Mines, Minerals Yearbooks, v. I-II, 1960-1970.

U.S. Bur. Mines, Coal-Bituminous and Lignite in 1971. Minerals Industry Surveys.

Table 10 presents a good picture of the present coal world markets. Under the Canada and Mexico heading most of the exports go to Canada; for instance, in 1971, a total of 17,565 M short tons went to Canada and the remainder to Mexico. The figures for Asia represent mainly Japan, the most important consumption market today. Western Europe is the other important consumption market that completes the world pattern. The Latin American market, although small, is important for the purposes of this study. In 1971, bituminous coal went to the following Latin American countries: Mexico, Argentina, Brazil, Chile, Peru, and Uruguay.

Might the U.S. be a potential market for foreign coal in spite of the amount of imports (Table 9) at the present time, its status as the largest exporter, and its inexhaustible reserves in the foreseeable future? It is my opinion that there will be an increasing market for good quality steam coals with low ash and low sulfur in the immediate future. Such a possibility is not due to exhaustion of known reserves but because of factors adverse to the industry. If the environmentalists continue applying strong pressure on the Government to adopt stricter standards and they are successful, the future of the coal industry could be very difficult. The opposite faction argues, with a valid reason, that this country is a world power and it can not depend too greatly for highly strategic energy commodities on foreign sources.

In the long-run it is to be hoped that a solution will be found that will satisfy both sides and will assure the safety and position of the U.S. in the world. A consequence of any such solution could be the importation of some amounts of high quality steam coals. Such imports would not create any problem of foreign dependence, given the volume of domestic coal output. This market should be located in the East- and Gulf-Coast areas where the electric power industry has operated, for definite cycles, below the standards recommended by the Federal Power Commission (FPC) (Beall, 1972, p. 41). Foreign suppliers could compete in those markets with low-sulfur western coals because of domestic transportation, restoration and reclamation of strip-mined lands, and increasing manpower costs.

The forecasts for the U.S. do not consider any importation of coal and they do not assume important changes in the present pattern of supply and demand. The National Coal Association estimates a demand of 696 million short tons in 1976. Chase Manhattan forecasts of 1088 million short tons in 1985 include coal to be used for syngas. The demand, without syngas, could be 960 million short tons (Beall,1975, p. 45).

U.S. Bur. Mines (Bull. 650, 1970, p. 51, 57) has the following forecast for bituminous coal and lignite for the year 2000 (million short tons):

	High Range	Low Range
Production	2,884	1,393
Demand	2,639	1,275
Surplus	145	118

It is expected that in the immediate future (within a decade) the coal output will increase at an annual rate of 4 to 5 percent (Lesutis, 1972, p. 97).

Canada. The Canadian coal output was 11,011 M short tons in 1960 and 10,673 in 1969. Over the decade the coal mining industry was rather stable. In recent years the Government has been taking measures to protect and encourage the industry due to the concrete possibilities of exporting western coals to Japan. Contracts signed with the Japanese in 1969 to provide 185 million tons over a 15-year period, starting in 1970 (Minerals Yearbook 1969, Vol. IV, p. 179), have stimulated strong development of the coal mining. The first results have been gains in output of 55 percent and 16.5 percent in 1970 and 1971, respectively. Exports which were only 1,375 M short tons in 1969, reached about 4,392 M short tons in 1970 and 7,466 M short tons in 1971. Of these, 4,123 M short tons and 7,181 M short tons went to Japan in the same years. Imports have been an important line of business in the Canadian coal economy. They were 13,565 M short tons in 1960, 18,864 M short tons in 1970, and an estimated 20,757

M short tons in 1971. The whole volume of imports come from the U.S.

This contradictory situation of large imports and a dynamic growing exportation market deserves an explanation. First, there are two producing coal regions: West and East. The West increased its production by 90 percent during 1970; the East decreased it by 24 percent, mainly because of difficult geological and mining conditions (Chrismas, 1972a, p. 171). Second, the industry and population are concentrated in the Eastern region which has a deficit of coal supply - 90 percent of the imports come to Ontario and the remainder goes to Quebec and Nova Scotia. Steam coal accounts for 50 percent of total imports. Studies of ways to move coal from West to East have been started, but the success of the operation will depend mainly on transportation costs. It seems likely, at any rate, that at least the present level of imports will be maintained, with the predominance of the U.S. in the market continuing because of its favorable location. Nevertheless, possibilities exist to enter the market with low-ash, low-sulfur steam coals because of the same reasons cited for the U.S.

There is no doubt that the western Canadian coal industry will continue to grow in the near future as a result of the Japanese contracts. Coal production is estimated to be 30

million short tons (Chrismas, 1972b, p. 152), with exports amounting to near 16 million short tons in 1975 (Tibbets, 1971, p. 79). According to recent information about Canadian contracts with the Japanese, the Canadians must supply them with 25.7 million short tons of coal by 1971 (Beatty, 1972, p. 93).

South Africa. This country emerged as a medium-sized exporter in recent years, although it has been an important producer for a long time. Its production was 52,847 M short tons in 1966 and 60,199 M short tons in 1970. For the same years, the exports were 1,221 M short tons and 1,421 M short tons, respectively. Exports will increase because of the contracts signed with the Japanese. Recently a contract to supply 2.7 million tons to Japan has been signed (Coal, Gold and Base Minerals, 1972a, p. 65). On the basis of future contracts, it is estimated that exports will amount to 15,400 M short tons during the period 1976-1980 (Coal, Gold and Base Minerals, 1972a, p. 63).

Australia. Australia is presently, and will probably continue to be, a big supplier of coal in the international trade. Output of bituminous coal and lignite was 61,734 M short tons

in 1966 and 81,227 M short tons in 1970. Exports accounted for 8,572 and 20,169 M short tons during the same years. Japan received 97 percent of total exports in 1969 and 90 percent in 1970. Australia is entering the Western European market to avoid depending on a single consumer. At present the Australian coal industry exports about 40 percent of its total output. It is worthwhile to point out that there were exports to Argentina and Brazil during the period 1970-71.

According to the long-term contracts with the Japanese, Australia must export 30.2 million short tons in 1975 and 39.3 million short tons in 1980 (Beatty, 1972, p. 23). Additionally, Australia is opening the door to West European coal trade successfully. For example, a contract was signed recently to sell 10 million metric tons to the largest Italian steel producer (ITALSIDER) over a 10-year period. This is part of a multi-million dollar sale contract for high quality coking coal negotiated in June, 1972 with Japanese and European steel producers. Half of the coking coal will go to U.S., France, Holland and Italy (Mining Magazine, 1972, p. 339).

Western Europe. In order to simplify this analysis, the U.S. and the "European Economic Community" - E.E.C. countries

(Belgium, Luxembourg, France, West Germany, Italy, and the Netherlands), which actually have the bulk of coal output and trade, will be studied.

For many years the Western European coal industry has been faced with serious problems due to ancient mines with low productivity and little mechanization, low output per man-shift (compared with non-European producers), increasing mining costs and decreasing proceeds, and strong foreign competition. In brief, coal mining is not a profitable business in West Europe. In order to avoid bankruptcy of the industry, the Governments subsidize it in amounts that reached in 1971 U.S. $5.94 per short ton in France, $7.43 per short ton in Belgium, and $1.59 per short ton in West Germany (Bradley, 1972, p. 112). The total amount of subsidies in 1970 was about U.S. $370 million.

The relevant figures for the coal industry in selected years were the following for E.E.C. countries and U.K.: In 1966, production--534,472 M short tons, exports--24,800 M short tons, imports--40,400 M short tons; in 1970, production--466,791 M short tons, exports--25,100 M short tons, imports--48,400 M short tons. There was a decrease, for the period 1966-1970, in production of about 13 percent and an increase in imports of about 22 percent. A lot of the international trade registered is among the countries of EEC and U.K. The main suppliers outside of the group are the U.S., Poland, the U.S.S.R., and others (Australia and South Africa).

Given the difficult conditions of the mining industry in Western Europe, imports will continue to increase, especially metallurgical and steam coals, and anthracite to a lesser degree.

Poland. At the present time Poland is the second largest coal exporter in the world after the U.S.

In 1966, Polish output was 161,744 M short tons of coal; in 1970 it was 190,553 M short tons. Exports reached 30,500 M short tons and 36,100 M short tons during the same years. Polish coal goes to Western Europe, Japan, the U.S.S.R., and other Eastern European countries.

Production of 214,000 M short tons of bituminous coal and anthracite and exports of 30,800 M short tons are estimated for 1980 (Bellano, 1971, p. 84). An important factor for the development of the coal industry in Poland is that it maintains a very modern coal research institute with a staff of 1,500 scientists with more than 500 patents to its credit (Bradley, 1971, p. 90).

U.S.S.R. and Mainland China. The two powers of the Communist world are respectively the first and third world coal producers, taking into account lignite production also.

Russian production of bituminous, anthracite, and lignite was 645,518 M short tons in 1966 and 688,000 M short tons in 1970. The U.S.S.R. exported 26,500 M short tons in 1966 and

26,800 M short tons in 1970, and it imported 7,490 M short tons and 7,800 M short tons in the same years. The production figures are run-of-mine. They diminish appreciably when converted into clean coal. The average ash content of the commercial coal was about 19.7 percent in 1971 (Mining Ann. Rev., 1972, p. 430).

The output of bituminous, anthracite, and lignite in mainland China was 360,000 M short tons in 1966 and 400,000 M short ton in 1970. The international market has not been important so far. In 1966 exports to U.S.S.R., Poland, and Japan totaled 965 M short tons. For 1970 there are no available data.

In brief, U.S.S.R. is a first order exporter while China does not have an important international trade. But both countries have a big potential export capacity.

Production of 689,000 M short tons of bituminous and anthracite, imports of 7,150 M short tons and exports of 31,800 M short tons is forecasted for the U.S.S.R. in 1980. The forecast for China is given only for production of bituminous and anthracite with a figure of 360,000 M short tons (Bellano, 1971, p. 84).

Japan. This small country is a giant in international trade as a consumer. Japanese imports of minerals reached 43 percent of all its imports in 1971. Japan paid U.S. $1 billion for coal imports during the same year.

Most of the demand is for high quality coking coals to fulfill the need of its dynamic steel industry. The domestic coal production was 57,093 M short tons in 1966 and 44,194 M short tons in 1970. Coal imports amounted to 22,100 M short tons in 1966 and 44,600 M short tons in 1970. Thus, there was an increase of about 101 percent in imports and a decrease of about 22.5 percent in output. Domestic coal mining faces a trend toward increasing costs, mainly because of difficult geological conditions. So the downward trend of domestic output will continue in the near future.

The commercial classification of coals by Japanese buyers are the following: a) Heavy coking coal with less than 8 percent ash. Over 75 percent is supplied by the U.S., the remainder by Australia, Canada, Poland, and the U.S.S.R. b) Heavy coking coal with an ash content of over 8 percent. Australia, Canada, the U.S., and the U.S.S.R. are the main suppliers of this type. c) Other coking coals which include high quality blending coals for coking purposes with less and more than 8 percent ash. The main suppliers of it are Australia and the U.S. (Loveless, 1972, p. 5). Japan also imports small amounts of anthracite and lignite.

The Japanese steel industry will continue depending on foreign sources for great amounts of coking coals in the foreseeable future, despite the decrease in the proportion of coke used in the blast furnace. The ratio of oven coke to raw steel output has declined from 0.81 in 1960 to 0.59 in 1969 and it is estimated to be 0.48 in 1980. Table 11 shows the demand for metallurgical coal by Japan in selected years and the suppliers according to signed contracts:

TABLE 11

Future Japanese Requirements of Coking Coal for Selected Years
(in million short tons)

Year	Japanese requirements	Australian contracts	U.S. contracts	Canadian contracts	Other Sources
1972	66.5	17.5	27.9	3.6	3.4
1975	72.8	30.2	13.4	24.0	5.1
1980	89.6	39.2	11.2	35.3	3.9

Source: U.S. Geological Survey and Occidental Petroleum Corporation, quoted from Beatty (1972, p. 88).

A diversification-of-suppliers policy plus difficulties with Canadian contracts (Wang, 1971, p. 34) are causing Japan to look for new importation sources. This statement is confirmed by new contracts signed with South Africa, credit agreements with the U.S.S.R. to build port facilities (Vrangel

Port) able to handle 10 million metric tons a year (Grube, 1970, p. 23), and the study of possibilities to import great amounts of coal from Mainland China.

Latin American Output and Trade.

The volume of international trade for the area is small, when compared with the countries or regions considered in the previous sections. Nevertheless, its analysis is important because of the decision to increase the intra-area trade through mechanisms approved by international agreements and the projects to expand, at any price, the steel industry in the region that will need increasing amounts of coking coals.

The Latin American Free Trade Association (LAFTA). The problems of small markets and the necessity to reach high rates of development to overcome the underdevelopment condition resulted in the movement toward economic integration of Latin America. So, in mid-1961 was born the LAFTA, established by the Montevideo Treaty. Initially it was formed by seven nations but now it is constituted by Mexico and all of South America except Guayanas (Fig. 1). Even though LAFTA has not reached the goals of economic development, it has had success in raising the level of regional trade. Trade among the members was U.S. $500 million in 1961. It reached about $1 billion in 1968 (Grunwald and others, 1972, p. 51).

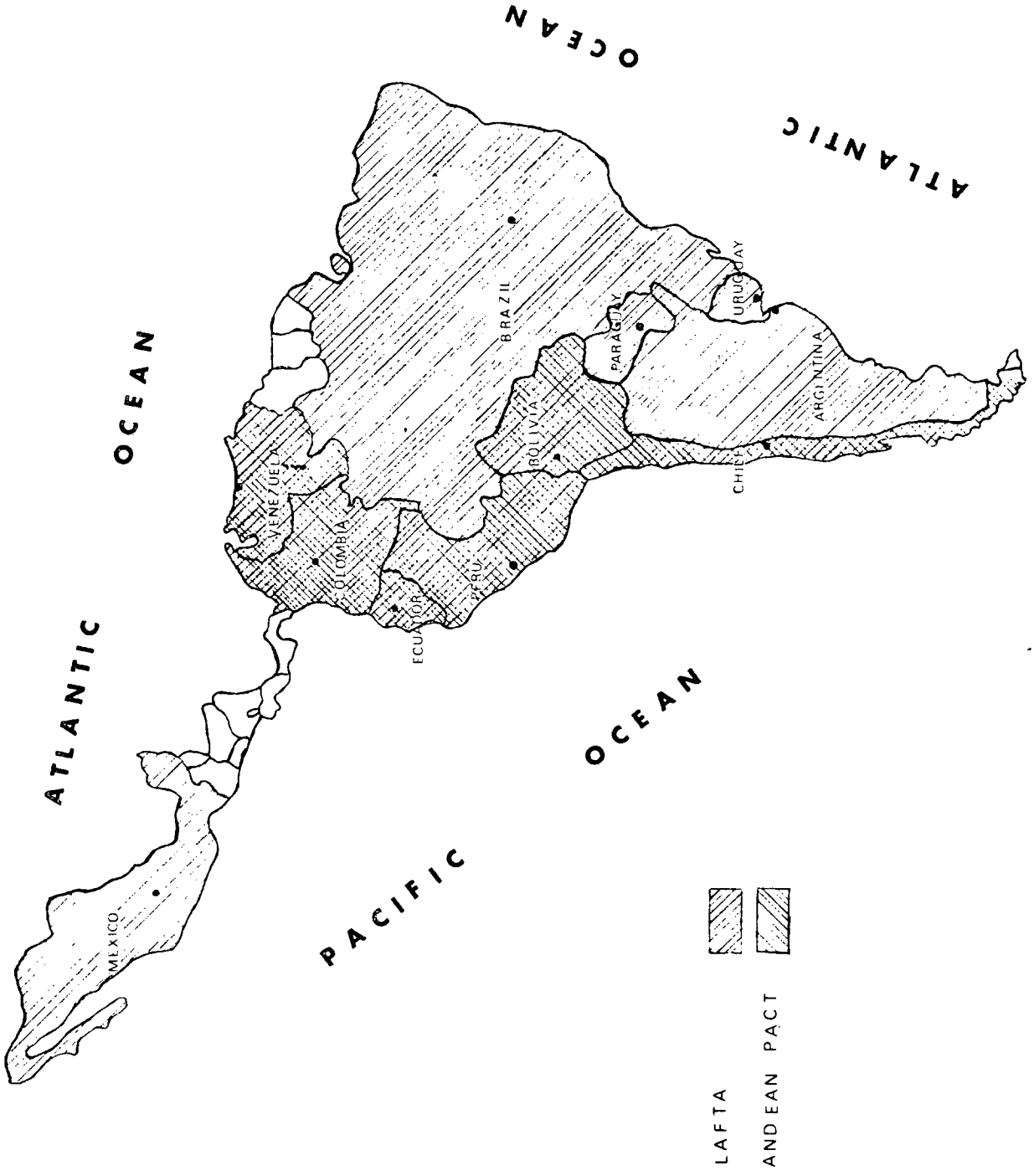

FIGURE 1.- Countries of LAFTA and Andean Pact.

In the previous decade, before LAFTA, regional trade had not registered any significant advances.

The possibilities of finding a market for Colombian coal are significantly enhanced by this increasing level of regional trade.

The coal-producing countries of the area are Mexico, Colombia, Brazil, Chile, Peru, and Venezuela in decreasing order of total output. Only Colombia and Mexico mine coking coals. All the countries, with the exception of Colombia, have to import coal and coke to meet domestic consumption needs. In 1965, Brazil, Colombia, Mexico, and Chile accounted for 93 percent of the regional coal output (Economic Commission for Latin America, 1967, p. 297).

Table 12 shows Latin American coal production since 1966 by countries. The same countries are also the steel producers of Latin America. Until 1970 Colombia had the greatest output in the area. In 1971 Mexico took the first position.

TABLE 12

Coal Output of Latin America Since 1966
(M short tons)

Country	1966	1967	1968	1969	1970	1971[P]
Mexico	2,316	2,632	2,872	2,709	3,262	3,696
Argentina	394	447	520	575	678	678
Brazil	2,363	2,530	2,606	2,685	2,609	2,751
Chile	1,821	1,649	1,776	1,878	1,664	1,789
Colombia	2,756	3,417	3,417	3,656	3,660	3,000
Peru	171	193	177	179	150	110
Venezuela	37	38	34	35	44	45
Total	9,858	10,906	11,402	11,717	12,067	12,069

[P]Preliminary

Source: U.S. Bur. Mines, Minerals Yearbooks, Vol. IV, 1967-1970.

U.S. Bur. Mines, Coal Bituminous and Lignite, 1971, Mineral Industry Surveys.

All the coal producers, except Venezuela, produce coke for their domestic steel industry; yet, all of them, with the exception of Colombia, have to import coal, or coke, or both.

Table 13 illustrates the output of metallurgical coke since 1966. Brazil and Mexico are the largest producers of coke and also of crude steel. Coal consumption in Latin America is closely related to industrial uses because it does not play any important role as a power generator due to the vast hydroelectric resources of South America.

TABLE 13

Latin American Production of Metallurgical Coke
(M short tons)

Country	1966	1967	1968	1969	1970
Mexico	953	1,135	1,271	1,258	1,433
Argentina	437	514	402	398	397
Brazil	1,367	1,444	1,550	1,661	1,797
Chile	255	316	335	349	350
Colombia	256	122	480	513	549
Peru	39	45	46	53	55
Total	3,307	3,576	4,084	4,232	4,581

Source: U.S. Bur. Mines, Minerals Yearbooks, Vol. II-III, 1966-1970.

The international coal trade of the seven steel producing countries, except Colombia, is characterized by net imports of coal and/or coke. Other countries outside of this group are also importers but the volume is so small that it is not worthwhile to consider them in a market study. Only Uruguay has a fair international trade.

Only coal imports coming from the U.S., as published by the Bureau of Mines (table 14), are considered here. Imports from other countries are usually insignificant; they also show an erratic nature that makes quantitative analysis of trends very difficult.

Table 15 shows total coke imports, with the exception of Mexico for which only U.S. imports are considered. Both tables reflect the import volume for only those countries which are significant for this study.

Given the fact that Colombia aspires to begin the international coal-trade business, but does not have the flexibility of the big exporters to adapt itself to the small customers, table 14 indicates that markets might be found in Mexico, Argentina, Brazil, and Chile. Table 15 shows also that Mexico and Venezuela are the only markets in the area for coke. Argentina and Brazil are possibilities if coke imports are added to coal ones. Therefore, forecasts for these above countries will be estimated later in this chapter.

The statistical data of the mentioned tables cannot be used as a reliable basis to begin a particular coal-exporting mining project, being subject to such irregular fluctuations. However, they still indicate the existence of a market and the possibilities to compete in it. Such a project demands more detailed market analysis with questionnaires and, better, interviews with the consumer firms.

TABLE 14

Latin American Bituminous Coal Imports from U.S., 1960-1971 (M short tons)

Country	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971
Mexico	57	54	51	47	53	60	53	62	74	116	173	285
Argentina	680	577	671	531	765	620	662	590	441	477	596	539
Brazil	1049	979	1316	1156	1101	1210	1739	1735	1787	1843	2020	1869
Chile	368	178	114	180	184	126	156	193	306	519	275	207
Uruguay	80	34	58	48	47	37	54	43	34	10	26	31
Total	2234	1822	2210	1962	2150	2053	2664	2623	2642	2965	3090	2931

Source: U.S. Bur. Mines, Minerals Yearbooks, 1963-1970, V. II-III.
McGraw-Hill, 1972 Keystone Coal Industry Manual

TABLE 15

Latin American Coke Imports During the Period 1960-1970 (M short tons)

Country	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
Mexico[1]	10	8	10	14	19	58	124	162	347	630	376
Argentina	77	51	25	2	76	90	57	43	34	51	NA
Brazil	33	48	30	43	168	137	64	48	69	97	NA
Peru	2	20	5	9	3	9	5	13	11	64[1]	39[1]
Venezuela	1	14	138	140	200	213	172	230	397	305	NA
Total	123	141	208	208	466	507	422	496	858	1147	NA

[1] These figures correspond to importations from U.S. only

Source: Institute of Geological Sciences, Statistical Summary of the Mineral Industry 1960-1965, 1966-1970,
U.S. Bur. Mines, Minerals Yearbooks, 1963-1969, V. II-III, Vo. IV.

Andean Common Market. The slow progress of LAFTA to achieve the goal of a common market and other political considerations produced the signature of Subregional Andean Integration Agreement, known also as Cartagena Agreement, in May 1969 by Bolivia, Chile, Colombia, Ecuador, and Peru. Venezuela, which participated in the negotiations, did not sign but it has the option to join the pact later. The Andean agreement was organized under the LAFTA rules and was approved by the full LAFTA membership.

The main achievements of the group have been: the establishment of the Andean Development Corporation, of which Venezuela is a member, with an authorized capital stock of U.S. $100 million to promote regional development; a common policy towards foreign investment; a common external tariff beginning with a minimum one by December, 1975 which must be implemented by the group at the end of 1985, and automatic and irrevocable reduction of tariff and non-tariff barriers to intra-Andean trade, aiming at free intraregional trade by the end of 1980 (Carnoy, 1972, p. 18).

The goal of free intra-regional trade is advantageous for Colombia, in the case of coal and coke, because it is the only country in the group that can export such commodities.

Even in the LAFTA area, the countries of which are coal importers, Argentina, Ecuador, and Uruguay have already eliminated ad valorem tariffs for anthracite and bituminous coal in the inter-area market (Poveda Ramos, 1971, p. 11); it is not difficult to get a similar agreement with other member countries at short term.

In the subregional Andean Agreement Colombia, Peru, and Chile are coal and coke producers, but Chile is the only significant importer (Tables 12-15). So, within this group, prospects are not good in the short-run. It may be that the only possibility is to finance multinational projects to export mainly outside of the region. This will be discussed in a later Chapter.

Forecasts. Using population and crude steel output (since over two-thirds of coal imports go to metallurgical coke production) as independent variables, a projection of the coal and coke imports for selected countries, using data of Tables 14 and 15 is given below. The source of data for the two independent variables is the United Nations Statistical Yearbook. The regression model will be of the form $Y = A + Bx_1 + Cx_2$. This linear form is preferable over a non-linear model (growth curve), because of the instability of the economies, the sectors of which are sharply influenced

by political and economic factors, and the lack of a dynamic and efficient growth of these same economies.

Projections of coal imports for Mexico, Argentina, Brazil, and Chile and of coke imports for Mexico and Venezuela have been made. The computer program used (ST 2001 [1700.5]) is designed to compare each pair of independent variables with the dependent variable. The program is designed to eliminate independent variables with very low correlation coefficient to the dependent variable. If both independent variables have a high correlation coefficient, the program deletes that independent variable with the lowest correlation to the dependent variable.

The following table registers the results obtained.

TABLE 16

Regression Equations and Results for Coal-and-Coke-Imports Projections

I. Variables:
Y = coal or coke imports (M short tons)
X_1 = crude steel output (M short tons)
X_2 = population (millions)

II. Coal imports
a) Mexico
$Y = 24.52 + 0.034X_1$
$R^2 = 0.595$

1975 175 M short tons
1980 247 M short tons

b) Argentina

$Y = 3{,}511.66 + 0.22x_1 - 141.08x_2$

$R^2 = 0.405$

1975	547 M short tons
1980	733 M short tons

c) Brazil

$Y = 320.17 + 0.30x_1$

$R^2 = 0.867$

1975	3,179 M short tons
1980	4,603 M short tons

d) Chile

$Y = -331.21 + 65.07x_2$

$R^2 = 0.318$

1975	381 M short tons
1980	463 M short tons

III. Coke imports

a) Mexico

$Y = -1{,}400.27 + 36.33x_2$

$R^2 = 0.731$

1975	788 M short tons
1980	932 M short tons

b) Venezuela

$Y = -2.23 + 0.35x_1$

$R^2 = 0.907$

1975	578 M short tons
1980	932 M short tons

c) Brazil. No good correlation coefficients could be obtained.

Note. Historical figures from 1960 to 1969, 1970 were used.

The author considers 1980 as a goal year to develop a coal mining industry in Colombia for exportation, given that we have to start practically from zero point. The 1980 results were subject to corrections (contingency forecast) of two percent up for the small amounts of Brazilian coal and Venezuelan coke imports and one percent up for Argentinian coal imports. This adjustment provides a median value for 1980. High and low values were obtained by adding and subtracting two standard deviations that cover about 95 percent of all the forecasted values. Table 17 shows the corrected forecasts for 1980.

TABLE 17

Forecasts of Coal and Coke Imports for Latin America in Year 1980 (M short tons)

		Low	Median	High
I)	Coal			
	Mexico	200	250	300
	Argentina	570	740	910
	Brazil	4,405	4,695	4,985
	Chile	220	460	700
	Total	5,395	6,145	6,895
II)	Coke			
	Mexico	970	1,190	1,410
	Venezuela	870	950	1,030
	Total	1,840	2,140	2,440

The Oficina de Planeacion (1971, p. 31) has quoted other sources as saying that the Siderurgica del Orinoco (Venezuela) has wanted to start buying 300 M metric tons of Colombian coke in 1970. These purchases were to reach 1 million metric tons in 1980, a figure very close to the above forecast. It is notable also that the Brazilian steel company, Vale de Rio Doce, has expressed wishes to purchase 200,000 metric tons of Colombian coal annually (Poveda Ramos, 1971, p. 9).

Fig. 2, from Table 16, 17 and 20, represents import trend of coal and coke, and 1980 forecasts for Latin America. The trends are not very regular, especially for coal imports. In brief, the median forecasts for 1980 are 6145 M short tons of coal and 2140 M short tons of coke, which, converted all into coal, using a coal-to-coke ratio of 1.5, give a total of 9355 M short tons of bituminous coal. A rational goal for Colombia would be to capture 50 percent of this market.

Prices

The price of coal is not standard because of different mining techniques, coal types, and different degrees of processing.

The only data available for the U.S. are the average price f.o.b. mines for the whole country and the average cost of coking coal at merchant coke ovens. Table 18 illustrates the price-trends from 1955 to 1971.

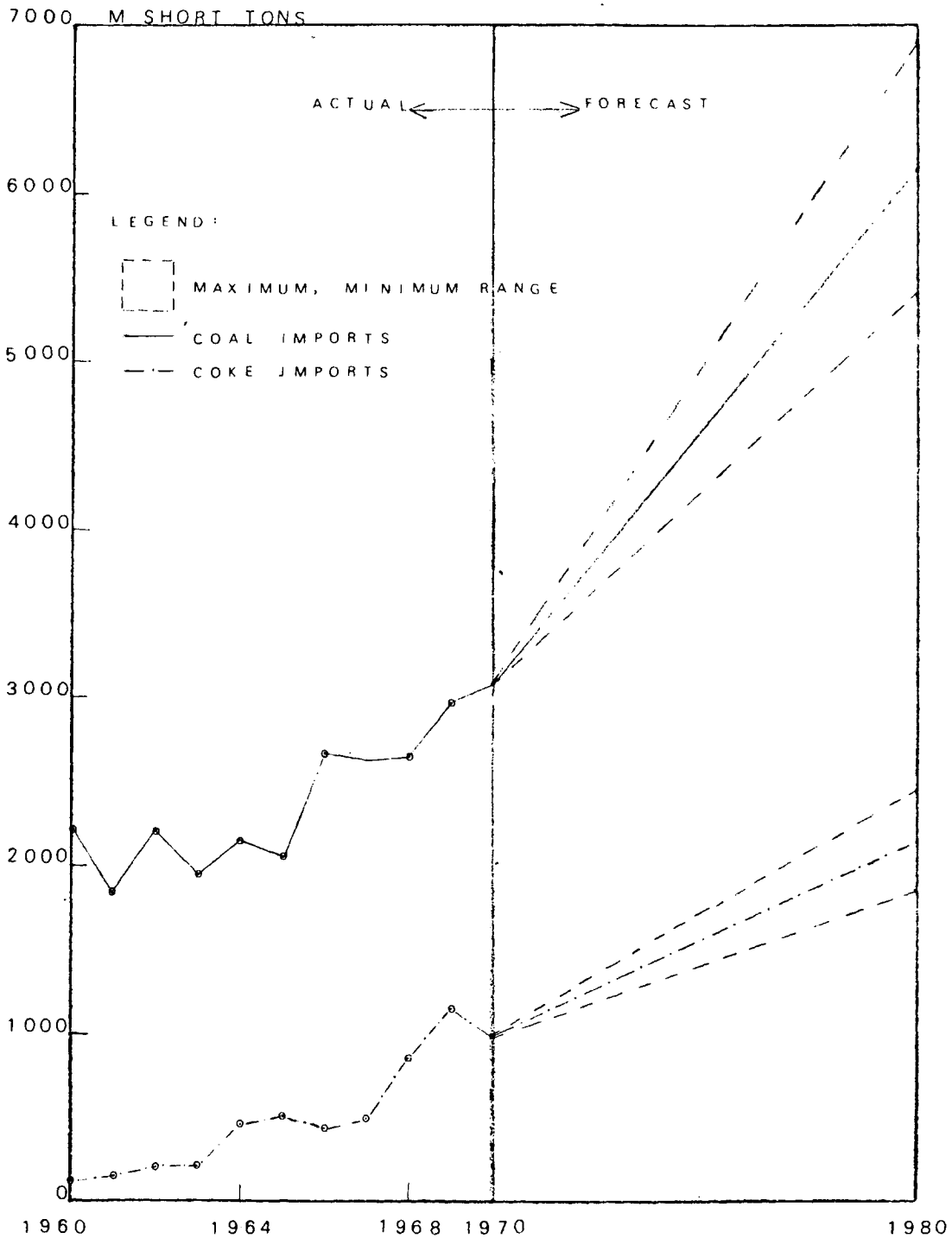

FIGURE 2.—Latin American coal and coke imports, and 1980 forecasts.

TABLE 18

Historical Prices for Bituminous Coal and Lignite, and Coking Coal Since 1955 in Current and Constant - 1968 - Dollars. (U.S. $/short ton)

Year	Bituminous and Lignite		Coking Coal	
	Current	1958 Dollars	Current	1968 Dollars
1955	4.50	5.87	9.16	11.80
1956	4.82	6.20	9.85	12.61
1957	5.08	6.29	10.76	13.22
1958	4.86	5.85	10.74	12.84
1959	4.77	5.71	10.45	12.60
1960	4.69	5.51	10.55	12.38
1961	4.58	5.30	9.83	11.40
1962	4.48	5.18	9.69	11.20
1963	4.39	4.98	9.35	10.60
1964	4.45	4.97	9.85	11.00
1965	4.44	4.85	9.65	10.55
1966	4.54	4.86	9.81	10.55
1967	4.62	4.80	10.33	10.55
1968	4.67	4.67	10.58	10.73
1969	4.99	4.79	10.75	10.20
1970	6.26	5.55	12.28	11.00
1971	7.07	6.05	15.32	13.16

Source: Adapted from U.S. Bur. Mines, Minerals Yearbooks, Vol. I-II, 1965-1970.
U.S. Bur. Mines Coal-Bituminous and Lignite in 1971, Mineral Industry Surveys.

At the beginning of the period there is an increase in prices until 1957. After that year until 1969 there is a decreasing price trend due to a continuous increase in productivity. But after 1969 the prices in constant dollars began to increase, mainly because of the implementation of the new Federal Coal Mine Health and Safety Act of 1969.

As a comparison, Table 19 shows the f.o.b. prices for Australian coals since 1966:

TABLE 19

Historical Prices of Australian Coal Since 1966 in Current and Constant-1968-Dollars, Per Short Ton.

Year	Current	1968 Dollars
1966	4.24	4.55
1967	4.34	4.52
1968	4.31	4.31
1969	4.66	4.42
1970	4.71	4.22
1971	5.35	4.59

Source: Adapted from Joint Coal Board 1970-1971, p. 295.

South Africa has a very low price per short ton, mainly because of the cheap labor cost. In 1969 the price was U.S. $2.46 for bituminous coal in domestic markets (Minerals Yearbook, 1969, Vol. IV, p. 643).

As to unit prices, it is difficult to get figures for each country of Latin America. The 1970 price per metric ton was U.S. $24.00 in Chile and U.S. $11.00 in Peru, whereas the Colombian coals have prices between U.S. $3.50 and U.S. $5.00 (Oficina de Planeacion, 1971, p. 65). For the same year the "Lota Schwagger" mine in Chile extracted coal from under the ocean at a f.o.b. mine price of U.S. $20.00 (Poveda Ramos, 1971, p. 16). According to the previous references, Colombian coals have one of the lowest prices in Latin America.

The average prices c.i.f. for imported coal by suppliers into Japan from 1967-1971 appears in the next table.

TABLE 20

Average c.i.f. Value Per Metric Ton for Coal Imported to Japan During 1967-1971 (in U.S. $'s)

Country	1967	1968	1969	1970	1971
U.S.A.	18.60	18.81	19.08	24.70	28.00
Australia	12.95	12.89	13.42	14.95	15.00
U.S.S.R.	14.38	14.08	14.41	15.35	17.60[1]
Canada	14.87	15.24	15.52	16.22	18.00
Mainland China	13.27	11.92	--	--	--
Poland	15.37	15.63	15.90	16.60	17.83[1]
South Africa	--	--	13.50	20.30	not available

[1] Average from the first six months of 1971.

Source: Adapted from Joint Coal Board 1969-1970, 1970-1971. U.S. Bur. Mines, 1971, Preprint Mineral Industry of Japan.

The data in table 20 reflect vertically the different types of coal shipped to Japan and horizontally the price fluctuations through the years. The price increases are generally due to the escalation clauses in the contracts to take into account changes in rail freights, port loading charges, changes in ocean freights, increasing mining costs, etc.

The most spectacular increases in price have been for U.S. coals during the last two years. They reflect the extra mining costs due to already mentioned causes. This trend can be disadvantageous in the long-run for U.S. in facing the competition. Nevertheless, Japan needs its high quality metallurgical coals for the present techniques of steel making.

COLOMBIAN COAL INDUSTRY

In this chapter, the location of the Colombian coal fields are presented with an indication of the coal rank wherever possible; the country's supply and demand profile, prices, and output forecast are studied; and the problems influencing the development of the domestic coal industry are identified.

Geography

Colombian deposits are widespread throughout the country (Fig. 3, 4, and Table 21). They are found along the three "cordilleras" (mountain ranges) that cross the country from south to north, the inter-Andean valleys, and the east "llanos" (plains). The most important deposits in terms of estimated reserves and rank are those along the East Cordillera from South Bogota to north of Cucuta. In the Central Cordillera, there are important deposits in Antioquia and Cordoba states. The West Cordillera contains the basins of Cali-San Francisco (Valle), Riosucio-Quinchia (Caldas and Risaralda), and Tado (Choco). So far, geologists have outlined about 32 coal basins throughout the country.

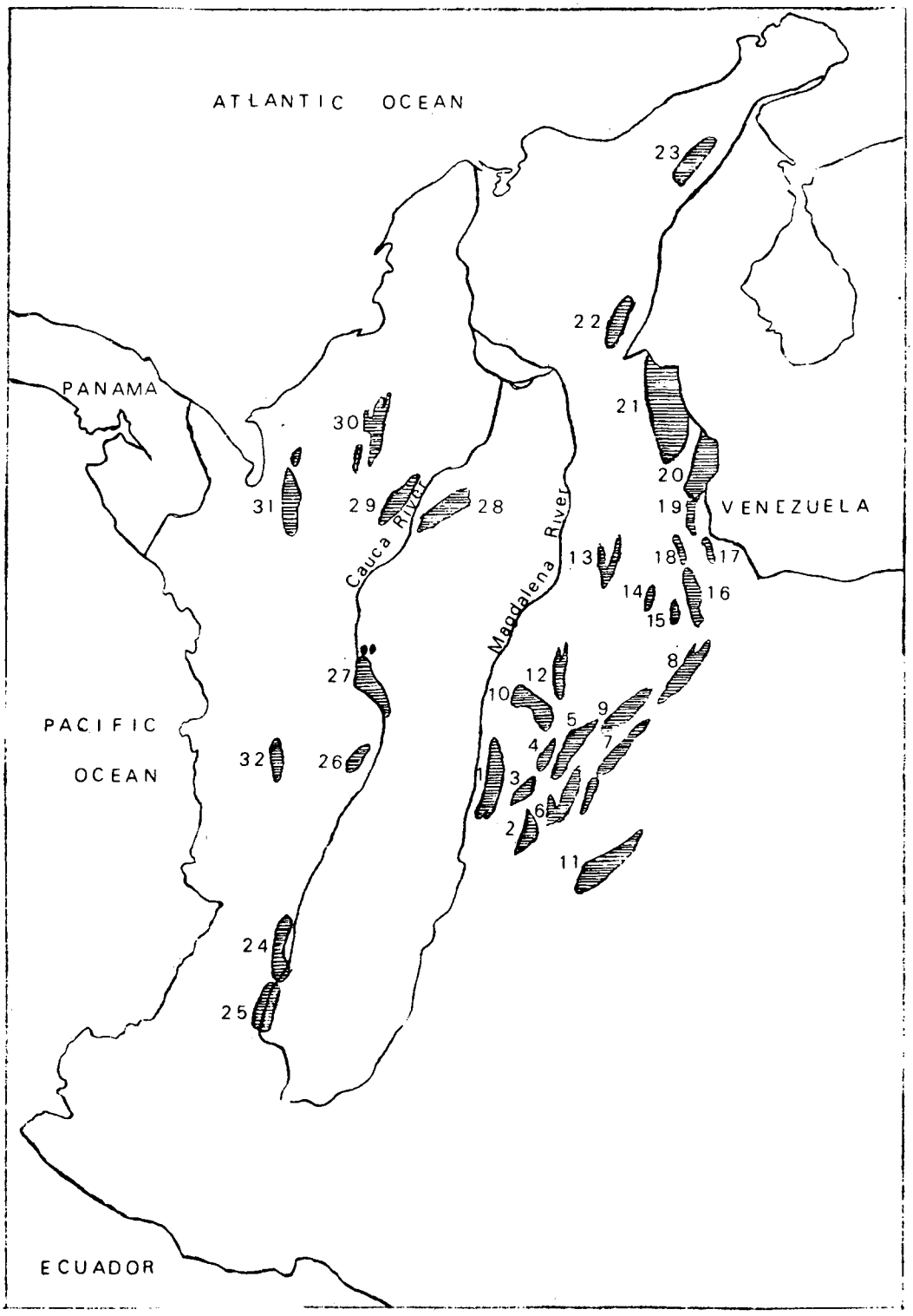

FIGURE 3.–Location of Colombian coal basins.

TABLE 21

List of Coal Basins in Figure 3

1. Pubenza-Dindal
2. Fusagasuga-Salto de Tequendama
3. Zipacon-La Pradera
4. Rio Frio - El Bosque
5. Cogua - Samaca
6. La Bolsa - Albarracin
7. Sueva - Laguna de Tota
8. Morca - La Uvita
9. Tunja - Duitama
10. Territorio Vasquez
11. Guatiquia - Borde E. Cordillera Oriental
12. Carare
13. Sn Vicente - Lebrija
14. Molagavita
15. Rio Servita
16. Paramo del Almorzadero
17. Toledo
18. Pamplona
19. Pamplonita - La Dn Juana
20. Rio Zulia
21. Sardinata - Tibu
22. La Jaqua de Ibirico
23. Cerrejon
24. Cali - San Francisco
25. Suarez - Dinde
26. Rio Sucio - Quinchia
27. Sopetran - Amaga - Poblanco
28. Puri - Caseri
29. Taraza - Caucasia
30. Alto San Jorge - Cienaga de Oro
31. Uraba
32. Tado

Source: Castro Orjuela (1970, Appendix: map).

FIGURE 4.—Political map of Colombia.

Basins. It is important to determine in general the coal rank in the different basins according to ASTM classification. For later use in economic analysis, the description will be by geographical units, taking into account the political division of the country into "Departamentos" (states).

Cundinamarca and Boyaca have 10 basins with bituminous, sub-bituminous, and semianthracite. Some of these basins contain good metallurgical coking coals.

Meta has one known basin but there has been no geological study of it.

Santander and Norte de Santander have 10 known basins. The most important ones are: Carare with anthracites and semianthracites; Sn Vicente-Lebrija with subbituminous and high volatile bituminous coals, probably coking coals; Toledo; Pamplona; and Pamplonita-La Dn Juana with high volatile bituminous, generally coking coals.

Cesar and La Guajira have two known basins: Cerrejon (La Guajira) and La Jagua de Ibirico (Cesar) with high volatile bituminous, probably not coking coals.

Valle and Cauca have two known basins. Coking bituminous coals and semianthracite occur in Cali-San Francisco basin.

Caldas and Risaralda have one known basin with bituminous and sub-bituminous coals. Some of them are coking coals.

Antioquia and Caldas have five known basins. The most important of them: Sopetran-Amaga with sub-bituminous and bituminous coals, together with some local occurrence of semi-anthracite; and Puri-Caseri where, according to a preliminary exploration, the coal is sub-bituminous with low sulfur and calorific value (see table 6). It is possible that the Alto Sn Jorge-Cienaga de Oro and Uraba basins have a similar rank.

Choco has one basin (Tado) where high volatile bituminous coal occurs.

Most of the previous data are taken from Castro Orjuela (1970, p. III-V).

Output and Trade

Domestic. Production figures for Colombia exist since 1928, with an output of 242 M short tons, to 1970 with an output of 3,660 M short tons. Table 22 shows the coal and coke production from 1955 up to 1970. These figures will be used later to make forecasts.

TABLE 22

Coal and Coke Production of Colombia, 1955-1970
(M short tons)

Year	Coal[1]	Coke
1955	1984	276
1956	2094	275
1957	2535	275
1958	2690	331
1959	2756	273
1960	2866	463
1961	3086	358
1962	3307	397
1963	3527	441
1964	3307	463
1965	3417	480
1966	3417	480
1967	3417	480
1968	3417	480
1969	3656	513
1970	3660	549

[1]Includes bituminous coal and anthracite production

Sources: U.S. Bur. Mines, Minerals Yearbook, Vol. I-II, 1958 - 1970.

Oficina de Planeacion, 1971.

Since 1963 coal and coke production has been almost stable, mainly because of competition from petroleum and natural gas (only in 1961 the Government took measures to

avoid the complete flaring of natural gas in the petroleum fields).

In 1969 between 50 and 60 percent of the output came from five big enterprises, with an annual output of 100 M metric tons and over, and five other with an annual output over ten M metric tons. The remainder was produced by medium and small-size mines. In the same year the following states shared about 86.5 percent of the production: Boyaca - 620 M metric tons, Cundinamarca - 550 M metric tons, Valle - 550 M metric tons, and Antioquia - 500 M metric tons. The integrated steel company (Acerias Paz del Rio, in Boyaca), the largest coal and coke producer, had an output of 560 M metric tons of bituminosu coal and 217 M metric tons of coke for its own use in 1969 (Oficina de Planeacion, 1971, p. 8 and 9).

A high percentage of coking coal is being used as steam coal; for example, 1969 out of a production of 1265 M metric tons of coking coal about 900 M metric tons were used to produce 465 M metric tons of coke (Oficina de Planeacion, 1971, p. 12). According to available figures, about 40 percent of the present coal output is coking coal.

The coal consumption by sectors is as follows: 58 percent in the manufacturing industries (textiles, cement, beverages, etc.), 30 percent in coke production, and 12 percent in electric utilities.

The main consumption centers and their consumption capacity are as follows (Oficina de Planeacion, 1971, p. 19-20):

a) Belencito (Boyaca) where the integrated steel company Acerias Paz del Rio has its own operations. Consumption capacity: 630 M metric tons of bituminous coal and 280 M metric tons of coke annually.

b) Bogota and La Sabana (Cundinamarca) with a market capacity of 450 M metric tons of bituminous coal annually.

c) Medellin (Antioquia), textile center, consumes about 400 M metric tons annually.

d) Cali (Valle) consumes about 600 M metric tons annually.

e) Manizales (Caldas), Bucaramanga (Santander), Cucuta (Norte de Santander), and Tunja (Boyaca) consume between 200 and 300 M metric tons annually.

International. For many years Colombia has exported small amounts of coal and coke and has imported coke chemical products. The following table illustrates the international-trade movement for the period 1960-1969.

TABLE 23

Colombian Coal, Coke, and By-products Foreign Trade 1960-1969

	Coke and Coal Exports[1]		Coke By-products Imports[2]	
Year	Short Tons	f.o.b. current U.S. $'s	Short Tons	U.S. $'s Imports
1960	250	4,142	1,937	429,749
1961	165	2,098	1,660	441,930
1962	468	6,281	1,771	389,932
1963	758	7,954	3,532	488,715
1964	3,630	60,755	4,680	559,119
1965	1,420	17,334	1,662	276,674
1966	895	13,253	3,305	638,562
1967	1,560	24,915	1,610	429,125
1968	3,088	46,869	2,505	535,382
1969	3,025	51,455	3,639	500,944

Sources: [1]Adapted from Oficina de Planeacion (1970, Table No. 75).

[2]Adapted from Oficina de Planeacion (1971, p. 24).

The coal and coke exports have gone mainly to Venezuela and Ecuador and sporadically to France, Belgium-Luxembourg, and Spain. At the end of 1957 10 M metric tons of washed coal were sent from mines in Valle State through the harbor of Buenaventura to France, but the project failed. In 1964 Carboneras del Carare (now Explotadora de Carbones Ltda.),

in Santander, exported 2,000 metric tons of anthracite to Belgium-Luxembourg and in 1970 10 M metric tons to Spain, but the company has not been able to organize a regular export trade. In 1971 there are registered exports of 171 short tons to the U.S. (may be as a sample for analysis).

The coke chemicals come from the U.S., Western Germany, United Kingdom, Netherlands, and Belgium.

Forecast. The same reasons that make it difficult to get good, reliable forecasts for Latin America also exists for Colombia. Initially, the author tried a multiple regression model to forecast coal and coke production, using as independent variable f.o.b. value of total exports (1968 U.S. $'s), gross value added of mining (1958 Col $'s), and crude steel production; but the results were not very reliable. Thus, the model was changed to a simple regression, using only crude steel production as the independent variable, since that was the one with the best correlation coefficients to the dependent variable. For the forecasts it was assumed that the trend of the past years is going to continue without major changes in interfuel competition, although it seems that the country can shift from a position of crude petroleum exporter to one of importer in a few years. Table 24 illustrates the resulting equations and figures.

TABLE 24

Regression Equations and Forecast Results for Colombian Coal and Coke Production (M short tons)

I) Variables

Y = Coal and coke production (M short tons)

X = Crude steel production (M short tons)

II) Coal Production

$Y = 1759.14 + 6.35 X$

$R^2 = 0.859$

1975	4102 M short tons
1980	4530 M short tons

III) Coke Production

$Y = 168.20 + 1.16 X$

$R^2 = 0.873$

1975	597 M short tons
1980	676 M short tons

Note: Historical figures from 1955 to 1970 were used.

For 1980 the regression model provides an output of 4530 M short tons of bituminous coal. A high value can be determined if it is supposed that the country will be successful in its coal exportation policy by capturing about 50 percent of the Latin American market and exporting another 2000 M short tons to other areas. A low value is obtained by subtracting two standard deviations. So the following forecast is obtained for 1980 year:

Low	4120 M short tons
Most likely	4530 M short tons
High	11200 M short tons

Fig. 5 illustrates the historical trend and projections of coal output for 1980. The projected figures include coal that goes to coke production. The following output has been projected by the Ofician de Planeacion (1970, table 25) for the years 1975 and 1980: 9477 M short tons and 9787 M short tons respectively. These projections include the projects of Carbones del Carare and Cerrejon which are destined basically for export.

In brief, it is possible to reach a strong development of Colombian coal mining at the end of the decade if the right and necessary steps are taken to encourage and develop the industry.

Prices. Colombian coal has the lowest price among the Latin American producers according to available data (see the previous Chapter). It is also the cheapest fuel in the country. Prices change with the different market centers according to the predominant regional mining structure. The consumers,

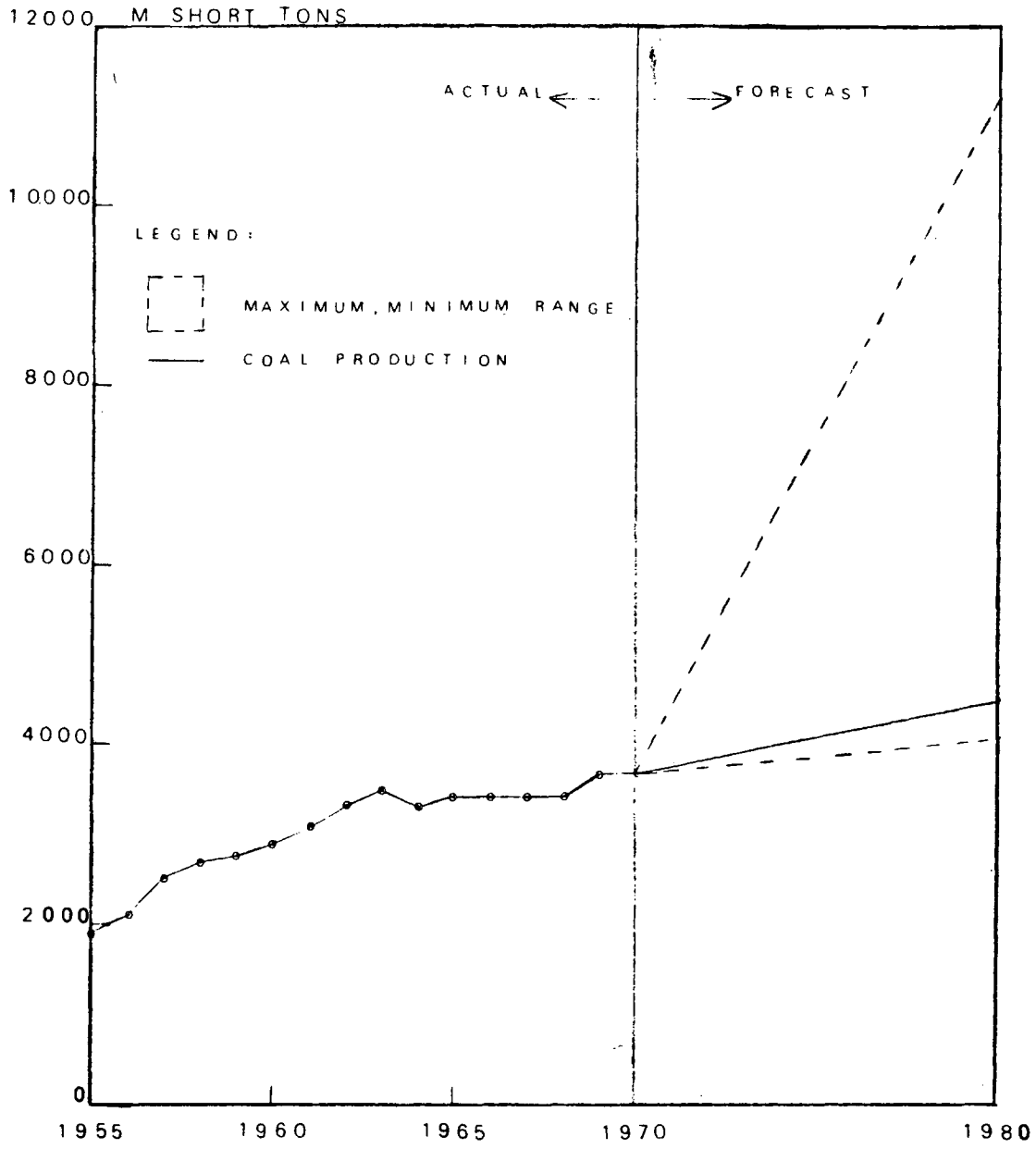

FIGURE 5.-Colombian coal production and 1980 forecast.

mainly from the industrial manufacturing sector, fix the prices to the medium and small-size mines which depend on the manufacturing industry for loans that they must pay with coal. Besides, there is an oversupply situation because a great number of small "family enterprises" where the daughters, little sons, and wife generally do not receive any salary. The relations between the small and medium producers, and the consumers could resemble the oligopsony model out of control. In brief, the big producers have an equal relation with the consumers regulated by contracts, whereas the small and some medium producers have a relation of subordination.

Table 25 shows the historical trend of the unit price per metric ton in the three main industrial cities of the country since 1960:

TABLE 25

Historical Unit Price for Commercial Coal in the Three Main Industrial Cities, 1960 - 1969
(Current and 1958 Col $'s per metric ton)

Year	Bogota Current $'s[1]	Bogota 1958 $'s	Medellin Current $'s[1]	Medellin 1958 $'s	Cali Current $'s[1]	Cali 1958 $'s	Purchasing Power of $'s[2]
1960	51.40	44.20	28.60	24.60	34.50	29.67	0.86
1961	54.00	44.82	34.85	28.93	40.50	33.62	0.83
1962	60.80	47.42	35.00	27.30	48.00	37.44	0.78
1963	64.00	39.68	41.60	25.79	77.90	48.30	0.62
1964	65.50	34.72	45.50	24.12	80.00	42.40	0.53
1965	72.30	35.43	45.50	22.30	83.oo	41.72	0.49
1966	74.00	31.08	80.00	33.60	85.00	35.70	0.42
1967	78.00	31.20	92.40	36.96	89.10	35.64	0.40
1968	81.00	30.78	98.00	37.24	92.00	34.96	0.38
1969	87.00	30.45	105.00	36.75	120.00	42.00	0.35

Sources: [1] Oficina de Planeacion, 1971, p. 21

[2] Departamento Administrativo Nac. de Estadistica, 1971, p. 16

To find the constant 1958 prices, the purchasing power of Col $'s (1958 = 1.00) was used as a deflator. The greatest increases in unit price (1958 Col $'s) after 1965 are registered in Medellin where two firms share about 50 percent of total output. In 1969 the unit price was higher in Cali than in the other two cities because the output was abnormally lower than the usual demand and it was necessary to buy the remainder in Medellin (Antioquia) at higher prices, so the average regional price increased (Oficina de Planeacion, 1971, p. 21).

Problems of the Industry

So far, the coal market has been analyzed at the international and local level. The results indicate high possibilities for a new exporter to enter the market. Now, the relevant factors that have decisive influence in the development of the Colombian coal industry will be studied. It is true that a great many of the problems affecting the sector stem from a state of underdevelopment, but this study will be concerned with those that have a direct relation to the coal industry pattern. Primary emphasis in this section will be placed on the organization of the industry for export market.

Exploration and Sampling. Regional geologic studies should be available when an exploration and sampling program for a coal field is started. Exploration and sampling are of utmost importance to determine the economic potential and marketability of a coal deposit. Coal has to meet strict specifications in all markets today. Narrow limits in moisture, ash sulfur, volatile matter contents, and other parameters such as carbonization test results, size, heat value, ash fusibility etc. are specified in purchasing contracts that are becoming standard procedure in international coal trade today. Besides, the pattern of the geological structure and the thickness, spacing, and persistency of the coal seams have to be determined to develop a good mining plan.

According to the practice of the countries where coal mining is experiencing a dynamic growth, the best method for a detailed evaluation is by a diamond-core drilling campaign. Such an approach provides the most accurate data for a detailed evaluation. It is expensive but justified when the big, future investments are taken into account. As Rushton (1973, p. 16) says:

> Even the preliminary evaluation of coking coal property is many times the order of magnitude of that for a base-metal property, and a full-scale evaluation to feasibility,..., will cost anywhere from 1.5 to 3.0 million dollars, depending on location, structural complexity, etc. However, the massive capital requirements for mine, plant, railway, townsite, and other facilities, demand that the chances of error be reduced as far as practicable, and the fundamental need of a sound geological and sampling framework cannot be overemphasized. The coking coals of Western Canada are so variable in thickness, ash content, and other characteristics, that a detailed program is essential in any evaluation.

The previous statement can be generalized for steam coals also, but it should be kept in mind that the intensity of the exploration study will depend on the market requirements.

Again, in the Colombian case, this decisive phase of a coal-mining project has received almost no attention. One or two big companies and a coal project in progress have introduced drilling programs but without getting complete utilization of it. This is one of the main reasons, by the way, that even the coke produced by the only integrated steel company of the country from its own mines is below the standard international specifications for metallurgical coke.

In short, any of the present operating Colombian firms in the sector cannot be used as an example to follow in starting a coal project. If Colombia wants to have a dynamic coal mining industry and a positive share in the foreign

market, the first step is to pay attention to the exploration and sampling in detail of coal properties, depending upon the end use of coal.

Mining Structure. The entire coal output in Colombia comes from underground operations. Five big companies produce 100 M metric tons or over and have some degree of mechanization and organization. Explotadora de Carbones Ltda. (old Carboneras del Carare) in Santander can be included in the big-producer classification because it has the capability of producing in that range. However, its output was only 42 M metric tons in 1969. Four of these companies have at least one mining engineer who has to perform other duties besides those of his profession. Only one (Acerias Paz del Rio) has a geology department to meet normal and exploration duties of the company.

Acerias Paz del Rio (Boyaca) and Industrial Hullera (Antioquia) use the "long wall" method in the coal face, with pneumatic hammers in the first and a coal-cutting machine in the second to mine the coal.

In the mines of Valle state with steep dips, the "panel" method is used, and in Carbones San Fernando (Antioquia) and Explotadora de Carbones Ltda. (Santander) the "room and pillar" method is used with pneumatic and/or hand picks to mine the coal.

The most mechanized operations employ chain and belt conveyors, diesel, storage-battery, and trolley locomotives for their underground transport, and individual electric cap lamps and safe-face (pneumatic-electric) lamps for the underground lighting.

However, the medium and small-sized operations, and in some cases even the so-called big operations, have a low degree of mechanization and they work with very primitive tools: hand picks for mining, human beings or wheel barrows for underground transport, candles or carbide lamps for lighting.

The general safety of operations is low. Only one company (Acerias Paz del Rio) has a whole body of safety rules for its mining operations and rescue crews functioning (the Government still does not have any legislation on mining safety).

Generally, coal is sold run-of-mine. There are three washing plants, two of which are in operation. These two belong to Acerias Paz del Rio and Explotadora de Carbones Ltda. The latter's plant has a capacity of 30 metric tons per hour. In 1959 a washing plant with a capacity of 125 metric tons per hour was build in Valle state to clean coals

aimed at export markets. It has been out of operation since 1964 due to the complete failure of the project (Oficina de Planeacion, 1971, p. 16).

The situation in coke production is similar. Fifty four percent of output is beehive coke produced in small units of 3 to 5 tons in capacity. There were about 708 of such units in the country in 1969 (Oficina de Planeacion, 1971, p. 11). Acerias Paz del Rio Company has a coke-oven battery of 43 units. It has also 65 beehive ovens at the Samaca mine.

In short, none of the present companies meet the mechanization requirements for an export-oriented coal industry.

Manpower. A high percentage of illiteracy, 70 percent or over as a conservative figure, is the common denominator among the mining workmen. When a new mining project starts, the general rule is to convert farmers and shepherds, without any previous training, into miners. The consequence is low skill among the mining people including foremen and supervisory personnel.

Another problem is that the supply of geologists and mining engineers is low. Table 16 shows the supply for some professions in 1964:

TABLE 26

Supply of College Educated Persons for Some Professions in 1964

Description	Number
Architects	1,459
Civil Engineers	3,172
Mining Engineers	70
Petroleum Engineers	117
Chemical Engineers	1,226
Agricultural Engineers	1,096
Physicians	8,274
Dentists	2,030
Economists	1,181
Lawyers	9,414
Geologists	70
Petroleum Geologists	85

Source: Icetex quoted from Oficina de Planeacion (1970, p. 21).

About 50 percent of the mining engineers are working in other activities. Also a high percentage of geologists are in the same situation.

The total manpower of the coal mining industry in 1963 was about 16,600 persons. They accounted for 22.7 percent of the employment and for 8.1 percent of the gross value in the mining sector including petroleum (Oficina de Planeacion, 1971, p. 1). During the same year, the total average employment in coal mining at the U.S., Canada and Australia was respectively 136,100, 6,670, and 16,800 persons, with a corresponding output of 570,978 M short tons, 10,673 M short tons, and 54,549 M short tons. By way of contrast, Australia

with about the same labor force reached an output 14.9 times greater than the one of Colombia.

Transportation Constraints. The purpose of this section is to analyze the particular state of the Colombian transportation system in relation to the development of a coal mining industry with some references to the Andean Region.

In a previous chapter, the three "Cordilleras" that cause the high ruggedness of the Colombian topography and the volume of difficulties for building an efficient transportation network were mentioned.

The total highway network of Colombia was about 45,000 km in 1969, of which 19,000 km were national, another 19,000 km departmental, and the balance municipal. Of this total, only 5,000 km were paved (Avramovic, 1972, p. 309 and 311). The efforts of the Government in recent years have been aimed at building a highway network linking the main population centers which are still somewhat isolated.

The railway system, under direct control of the Government by means of the Colombian National Railroads Office, accounts for 3,436 km of a unified network connecting the Pacific port of Buenaventura through the main industrial centers with Atlantic port of Santa Marta. Topography is responsible for multiple grades along the system - from less

than 1 percent to a maximum of 4.6 percent and an average exceeding 2 percent (Avramovic, 1971, p. 321). This condition, plus poor track, is responsible for low flexibility and efficiency of the rolling equipment. The truck costs are lower than equivalent rail costs in mountainous terrain in Colombia. The revenue in 1969 per ton-mile of the entire Colombian railroad system was U.S. $0.025. The range was between U.S. $0.022 to U.S. $0.128. In the same year truck costs ranged from U.S. $0.020 to U.S. $0.049 (Avramovic, 1972, p. 329). In 1971, the transportation costs by road and rail between major Colombian cities and ports were respectively U.S. $0.025 per ton-mile and U.S. $0.026 per ton-mile (Morawetz, 1972, p. 21, 33, and 42).

The Magdalena River has been the main waterway for transportation from Atlantic ports to interior cities. It is estimated that the river transportation costs are two-thirds of rail tariffs on a ton-km basis (Avramovic, 1972, p. 329). The river is navigable from Honda to its mouth near Barranquilla along a length of about 580 miles.

Overland transportation among Andean and, in general, Latin countries is more difficult than within Colombia itself. The only possibility to export coal by such means is to Venezuela from a well situated deposit near the border line. Thus, ocean transport is the only alternative for such trade. The unit ocean freight rates are higher among

Latin American countries than between Latin America and the rest of the world (Morawetz, 1972, p. 6). The relevant reasons mentioned for that situation are: low volume traffic, low capacity of ports and lack of freight handling equipment for bulk materials in them, and the policy of big marine transportation companies. These companies look for the reduced costs and increased profits which are made possible today by large ships and the so-called combination trade. The ideal combination trade does not require ballasting in a round trip. To meet this requirement, ships must be designed to carry different commodities such as ore/oil, ore/bulk/oil, or ore/slurry/oil (Roberts, 1971, p. 71). Some ocean transportation companies, such as Marcona, use operation research techniques to determine the most profitable combination trade routes and to eliminate marginal routes (Roberts, 1971, p. 73). In short, the low volume of international trade and port conditions of Latin America are not attractive for this particular business.

Table 27 is a summary of costs for different systems of transportation in Colombia and the world.

TABLE 27

International and Colombian Figures for Transportation Costs by Different Means (ranges)

Colombian costs (U.S. $'s/ton-mile)

Ocean shipping[1]	0.007 - 0.022
River barge	0.015 - 0.085
Rail	0.022 - 0.128
Truck	0.020 - 0.049
Ports: Loading	2.89
Unloading	9.80

International cost ranges (U.S. $'s/ton-mile)

Ocean shipping	0.0003 - 0.010
Pipeline	0.0015 - 0.010
River barge	0.002 - 0.004
Rail	0.004 - 0.015
Truck	0.055 - 0.070
Ports: Loading	0.10 - 0.15
Unloading	0.25 - 0.40

[1]These figures are among Andean ports, for selected commodities, and for low-volume materials. The freight rates from Andean ports to New York and Antwerp (Europe) are respectively about one and a half, and two and a half times lower than within the area.

Sources: Avramovic, 1972, p. 329
Morawetz, 1972, p. 26-30
Maddex and Skaarup, 1970, p.57
Mining Engineering, 1970, p. 55

Truck rates for Colombia are the only ones comparable to international standards, although it is necessary to point out that international figures are for bulk commodities whereas Colombian ones are for all imports, generally low volumes.

It seems that if a modern transportation means is selected and built for each coal project, following a detailed feasibility study, the international ranges of freight rates could be reached.

The present capacity of seaports meets the whole international trade requirements of the country. However, at the present, there are no port installations specifically designed for the export of a bulk mineral commodity such as coal.

Fiscal Policy. The Colombian tax law is complex and voluminous. The following section of the study will attempt to summarize that portion which is important to the management of a foreign firm in making an investment decision in Colombia.

The income tax rates on corporations, national or foreign, is as follows: 12 percent on the first Col $100,000 of taxable income, 24 percent for income of over Col $100,000 to Col $1,000,000, and 36 percent in excess of that. Foreign corporations are subjected to a 12 percent tax on dividends or profits remitted outside of the country. All corporations have a tax on excess profits that is based on income after tax minus 12 percent of patrimony (net assets). If this result (called "excess profits") is up to 6 percent of net assets, the rate for excess profit tax is 20 percent. This

rate continues to increase gradually up to 56 percent when the excess profits are over 36 percent of net assets. The following example shows the mechanism of the excess profits tax:

Net assets (patrimony of a company)		Col $1,000,000
Income after taxes		180,000
Excess profit tax base:		
180,000 - (.12x1,000,000)	=	60,000
6 percent of 1,000,000	=	60,000
"Excess profits" tax = 60,000x.20	=	12,000
Income after excess profits tax =		
180,000 - 12,000	=	168,000

Besides these taxes, there are normally surtaxes for specific purposes such as social security tax, housing tax, electrical development tax, etc. that change through time. They are calculated on a variable basis: taxable income, income after taxes, or net assets. A weak point of this tax structure from the investor's point of view is the impossibility to carry-forward and carry-over losses from a particular year.

Depreciation allowances are based on any accepted method of the developed countries, with a compulsory salvage value of 10 percent on 5, 10, and 20 years according to three classification categories. Generally the straight

line method is used. Exploration expenses have an allowance up to 10 percent of the annual cost. The depletion allowance is 10 percent on gross value, f.o.b. mine, less royalties (coal mining does not have royalties). That value cannot exceed 35 percent of net income before depletion allowance (Dias de Frias, 1970, p. 17).

Mining companies are exempt from patrimony (net assets) tax as are all corporations and also from custom taxes on the import of equipment for the different steps of the process.

The most recent stimulus to the mining industry came from a tax credit certificate (Certificado de abono tributario-CAT) established in 1967 by the Government to promote exportations different from the traditional ones (Avramovic, 1972, p. 127). This tax credit is an amount equal to 15 percent of the total value of the export. Also it is negotiable: it can be used to write-off taxes or it can be redeemed for cash a year after issue. Coal exportations are eligible to receive it (Oficina de Planeacion, 1971, footnote, p. 26).

One other important point is the recent regulations on foreign investment to comply with those of the Andean Group adopted under Decree 1234 of 1972 from Republic's President and Resolution 17 of 1972 from the National Council of Economic and Social Policy. These regulations encourage the

creation of joint ventures to exploit Colombian resources. Their main points are the following:

> In its study for foreign investments, the National Planning Department shall take into consideration the potential new employment opportunities offered, utilization of national raw materials, participation of Colombian citizens in its administrative, technological and commercial development, and its effect upon and contribution to subregional and Latin America integration.
>
> Foreign investment to create new enterprises which will take advantage of the liberalized trade incentives provided by the Cartagena Agreement (Andean Group) will only be approved if participation by national investors is a minimum of 15 percent when the project starts, 45 percent within 10 years, and 51 percent in 15 years. (Colombia Today, 1972, p. 5).

The regulations stipulate also that the foreign investor can make profit remittances up to 14 percent of the registered net investment annually. They authorize the Royalty Committee to approve or deny the registration of contracts for royalties, commissions, use of trademarks and patents which cause transfer of money abroad.

It is difficult to evaluate the influence that these measures will have on foreign investment at the short run. The only clear thing is that this policy is coming to be a general trend among the suppliers of raw materials. An American journalist in a recent publication on the subject

(Harvard Business, Rev., 1973, Vol. 51, No. 1) is optimistic about the feasibility of American enterprise making profits even with the new rules of the game of the Andean Group (Utley, 1973, p. 86).

POTENTIAL DEVELOPMENT OF COLOMBIAN COAL INDUSTRY

Having completed a detailed analysis of the market areas, this chapter examines: (1) the real prospects for Colombian coal in foreign and domestic markets; (2) the more favorable coal fields for an early development to meet that potential demand, taking into account the existing constraints.

Colombia has to keep in mind that, in order for its coal-mining industry to grow, it must move into the international market. Concrete facts have demonstrate the possibilities to enter the international market. Irregular export to the neighboring countries (Ecuador, Venezuela), the interest of corporations in Latin American countries such as Brazil, Venezuela, and Mexico to import Colombian coal and coke under the privileges of the subregional agreements, and the unsuccessful projects in the past to export to Western Europe and Japan show that the possibilities exist, but the country has not been able to develop them.

The most recent development in the sector has been the attainment of an agreement between the Instituto de Fomento

Industrial (Development Industrial Institute) of Colombia and the Peabody Coal Company of the U.S. for a joint venture in order to mine the Cerrejon coal deposit (Guajira) aimed to the export markets (Flash, 1972, p. 8). The total investment will reach about U.S. $120 million. The data source does not provide information about annual production or percentages of investment by the government and the foreign firm. Another significant development is that Colminas, a mixed company (private and public participation) of Colombia,

> ...plans to install a coke plant with an output of 1 million tons/year, to be exported to other member countries of the Andean Group which have undertaken to buy the entire production. The total investment in this project, including the construction of port loading installations, will exceed Col 500 million pesos. It is estimated that the exports proceeds will total 40 million/year". (Mining Jour., 1972, p. 52).

Local Trade

The forecast for domestic coal consumption (table 24) is very realistic because it considers the trend of the last 16 years. The dependence of the industry on a domestic market means that all the present problems of the industry will continue, especially the conditions of underemployment for most of the labor force and the waste of the natural resource.

The oversupply condition, the modest annual rate of growth of the steel industry, and the low use of coal for power generation do not indicate a good future for the coal

in the domestic markets.

According to the plans of the Instituto Colombiano de Electrificacion (Colombian Electrification Institute) for the next 10 years, 71 percent of the electric power will be generated by hydroelectric facilities. This percentage is greater than the present rate of 69.7 percent (Oficina de Planeacion, 1971, p. 63-64). The surplus up to 100 percent has to be shared by coal, petroleum products, and natural gas.

A reconsideration of this policy to allow a greater share of power generation by thermoelectric plants would provide a stimulus to the domestic coal industry and a stable market to organize medium and small-sized mines, would help to solve partially the underemployment problem, and would contribute to finance this industry.

International Trade

LAFTA and Andean Group. The existing volume of coal in the regional market and the expected growth in the future (tables 14, 15 and 17) constitute a good goal for a new exporter, but there are two relevant factors to which attention must be paid: the quality of the coal that the area needs and the bottleneck of ocean transportation.

Most of the coal imported today to Latin America is coking coal for steel-making purposes. Blending of coals to make coke is the general practice today, as no individual coal meets all the required specifications. According to the present practice in the U.S., the proportions of the different types of coal to obtain a good metallurgical coke are as follows: 21.4 percent of low volatile bituminous coal, 12.3 of medium volatile, and 66.3 of high volatile. The ranges in volatile matter are 14-22 percent for low, 22-31 percent for medium, and over 31 percent for high. The coal mined by Latin American importers is of a very low quality, except perhaps that of Mexico. This situation compels them to import high quality blending coals. Thus, it will be necessary to develop deposits of low and medium bituminous coals to meet the demand of this market. Colombia seems to have most of the deposits of high bituminous, according to the known analyses (table 6).

To insure these qualities for Colombian coal exports, it will be needed to negotiate agreements and contracts with the consumer firms, and to carry detailed exploration of the deposits to meet the requirements of the market, before starting the final investment to put a project into operation.

A few alternatives will be considered in the next paragraphs in relation to the ocean transportation problem.

a) Joint venture with multinational firms. The foreign firm will take charge of the operation and marketing of the coal. When a foreign firm reaches such an agreement, the ocean transportation problem is eliminated.

b) Contracts with ocean transportation companies before starting the final phases of a project. This is difficult because the ocean transportation firms of bulk commodities delete marginal areas according to its optimization models.

c) Use the resources of the area to create joint ventures with regional capital and transport the coal by their own means. Economically this alternative represents a sacrifice quota for the members. They are going to receive an inferior product compared with international standards at higher costs because these countries have a common problem: They do not have the know-how for mining and marketing coal at competitive levels. Besides, to have competitive ocean transportation costs, it is necessary to look for some trade combination system.

The first solution is the most advisable for Colombia. A complete success requires that it be aimed not only to Latin American markets but toward other areas as well.

Other Markets. This section deals with the rest of the world as a potential market for coal exports from Colombia.

Two million short tons were projected for exports to other areas when forecasts were made in a previous chapter. This amount could go to the U.S., Canada, Japan, and/or Western Europe. For these markets blending bituminous coal for coke production and/or steam coal would be the main types exported. The figure of the forecasts is conservative. Probably it is more feasible to set higher amounts in these markets than to reach the goal fixed for Latin America.

The coal to be exported can be subdivided in two groups: coal going through the Atlantic Ocean and that moving in the Pacific area. According to previous forecasts these groups can be distributed in the following form for 1970:

a) Atlantic Ocean

Brazil	2,350 M short tons
Argentina	370 M short tons
Venezuela	710 M short tons
Mexico	510 M short tons
Others	1,500 M short tons
Total	3,440 M short tons

b) Pacific Ocean

Mexico	510 M short tons
Chile	230 M short tons
Others	500 M short tons
Total	1,240 M short tons

About 82 percent of the volume would be moved through the Atlantic ocean. This result determines priorities to follow in the prospecting and exploration of coal deposits.

At the present time there are two projects for coal exports in progress: Explotadora de Carbones Ltda. (Santander) that started about 9 years ago but it is not still operating normally, and the Cerrejon Basin where initial phases of prospecting and exploration have been undertaken by a government organization.

Taking into account the two mentioned projects, Colombia must negotiate future coal projects aimed to exports with a maximum of three different foreign companies with coal experience to obtain more efficiency.

The most favorable basins besides Cerrejon and Carare that Colombia could study are the following (see Fig. 3):

a) Pubenza-Dindal Basin. It is known to cover 900 km^2; it has coal ranging from medium to high volatiles and probable coking coals; it is crossed by an important highway (Bogota-Honda) and railroads (Bogota-Girardot-Santa Marta, Bogota-Puerto Salgar-Santa Marta); and it is near to the site where the Magdalena River begins to be navigable (Honda). One important point is that there are no known coal mining activities in this basin at the present time. Potential reserves of 4 billion metric tons have been estimated (Castro Orjuela, 1971, p. 1, table 1).

b) Rio Zulia Basin. It extends from 20 km SW of Cucuta for 70 km to the NE up the Venezuelan border. It covers an area of 750 km^2. The coal is high volatile bituminous and probably coking. There are some small, and median coal operations in the basin. It is crossed by the international highway linking Colombia to Venezuela. This basin could be an important source of export coal or coke for Venezuela. Potential reserves of 1,875 million tons are estimated for it (Castro Orjuela, 1971, p. 14, table 1).

c) Cali-San Francisco Basin (Valle). The potential amount of coal that could be exported through the Pacific Ocean justifies a detailed exploration of it to determine its feasibility to compete in export markets. It is located in the Valle Department near the Pacific port of Buenaventura. Although it has coking coal, the mining conditions are difficult and the coal has high ash and sulfur content (Castro Orjuela, p. 17, table 1).

The coal to be moved through the Pacific Ocean can come also from basins with overland transportation to the Atlantic Ocean. Then it can be transported through Panama Canal to

the Pacific areas. This is the way followed by the U.S. coal exports to Japan and other Pacific regions.

DEVELOPMENT STRATEGIES FOR THE INDUSTRY

The goals pointed out for the Colombian coal industry in 1980 require an aggressive policy to reach them. A comprehensive strategy for the entire mining industry is necessary to obtain a complete success.

During recent years the Government has taken measures to correct several of the causes responsible for the slow development of mining. Among them the most important are: The Laws 60 and 20 of 1967, and the Decree 1275 of 1970 to modernize the mining code; a national program of mining training for workmen and supervision personnel initiated by the Servicio Nacionad de Aprendizaje-SENA-(National Service of Apprenticeship), with the technical assistance of the French Government; the creation of public organizations to intervene in the different steps of mining development such as the National Institute of Geological and Mining Surveys (INGEOMINAS) and the Colombian Mining Enterprise (ECOMINAS); regulations on foreign investment permitting the repatriation of capital and remittance of reasonable profits in order to help the financing of the industry; and

Resolution 002904 of 1971 to regulate credit for medium and small-size mines which can receive also technical assistance.

In addition to the measures taken so far, it is necessary to provide specific ways of action to be followed for the development of the coal industry. Thus, aspects of organization, financing, and research will be analyzed.

Government Planning

The national businessmen do not invest in mining projects because, first, they prefer other kinds of activities with lower risks and faster profits such as manufacturing, commerce, or real-estate ownership; and second, the mining industry is a highly capital-intensive one, whereas the indigenous capital, especially foreign currency, is scarce. This condition demands the direct intervention of the government as a regulator and investor in the sector.

This is the particular situation of the coal mining industry where the government has to exercise the two roles: regulator to protect the technical and safe exploitation of coal, and investor to encourage the development of the sector. Without these measures coal mining will not make any significant progress as experience has demonstrated in the past.

Once the government has filled the investor role, it must prepare to transfer its stock to private investors in

the long-run, according to the economic structure of the country: a mixed, predominately capitalist society.

The intervention of the government may reach any of the four possible forms of organization of the coal industry: (1) wholly foreign-owned companies, (2) joint ventures, (3) large national companies, and (4) medium and small-size operations. However, this study does not consider the wholly foreign-owned company alternative, due to the fiscal stimuli that are now, and will be in the future, provided to the joint international venture. It seems that the importance and number of wholly foreign-owned companies operating in Colombia will decrease in the near future. It must be clear that government intervention mentioned above must be limited to the supervision and control of the wise exploitation of the natural resource.

Joint International Ventures. What is a joint venture? Friedmann and Kalmanoff (1961, p. 6) say that

> ...in the widest sense, the "joint venture' comprises any form of association which implies collaboration for more than a very transitory period.

A more understandable definition is the following:

> ...a joint venture is a business enterprise in which two or more economic entities from different countries participate on a permanent basis. The participation is not limited to equity capital but normally extends to control of undertaking through manufacturing processes, patents, trademarks, managerial knowhow, or other operationally essential factors. (Kolde, 1968, p. 260).

One form of organization that may achieve success in Colombian coal-mining projects aimed toward export is the "joint international venture" among foreign companies and the Colombian government, public or private organizations of the Andean Group, and/or national private investors. This type of enterprise among private companies an/or public organizations of the Andean Group, as one author suggests (Poveda Ramos, 1971, p. 16), would be facing the same problems, especially of know-how and marketing, as Colombian enterprises may face.

The selection of the foreign firms for negotiation of joint ventures is a decisive factor for success. They must have broad experience, from mining through preparation to marketing. Coal companies, such as those operating in the growing exporting countries (Canada and Australia) are probably the most suited for joint ventures.

Following an agreement for a joint venture, the government has another important role in controlling labor unions. Their pressures for increases in salaries without a corresponding increase in productivity are very common in Colombia. This situation can put a business out of competition, especially in the international trade. All the increases in salaries would be justified with increased productivity. This task is easier when the government participates in the enterprise.

Often, there is a general feeling of mistrust about direct participation by the government in an enterprise, but there is a difference between government-operated companies and companies with government participation. In a joint venture, the experienced foreign company will direct the operations, at least in the first years of the project, until the national personnel becomes skilled. On the same problem, as it is related to the iron and steel industry in Latin America, Golson (1968, p. 167) writes:

> ...in these developing countries subject in many cases to growing pains, such as political or economic crises, the only relatively stable entity is the government itself. It is recognized state-owned or state-controlled enterprises are sometimes subject to political pressures in their policy or in their administration or even to carpetbagging. However, until these nations acquire stability, this is the only possible solution to operating large enterprises such as those of the iron and steel industry.

A relevant question now is when must Colombia begin to take the first steps on the way to joint ventures for the development of its coal deposits? There is reason to think that the U.S. big coal-mining companies are willing to study alternatives of investments in foreign countries, given the present circumstances of the coal mining here. The Secretary of the Interior in his first mineral report (1972, part 1, p. 2) says:

> Evidence is also accumulating that investment in domestic mineral development is losing its attractiveness; that investment in foreign mineral development is potentially more rewarding, despite the fact that important major foreign subsidiaries of U.S. mineral firms have been nationalized.

Many developing countries are trying to attract foreign investment from developed ones; if Colombia does not act now, others will get ahead.

Large National Companies. Most of the large national companies in Colombia are vertically integrated. By improving their operations, they could meet the demand of the local market. To reach this goal they need mechanization and financing to improve and expand operations.

One of the public mineral organizations, with adequate knowhow and technical instrumentation, ought to study the mining plans of these large companies for an extended period of time, to be sure that these corporations are making efficient use of the national resources.

Medium and Small Size Operations. This category is characterized by lack of technical knowledge, unskilled manpower, marketing problems, and financing difficulties. The damage these operations cause to the national economy is irrevocable.

The problem of small firms has affected the coal industry throughout the world with perhaps the exception of new

exporting countries (Canada and Australia). The fast and dynamic growth of the industry in these countries is due mainly to the operation of multinational corporations. In the U.S., there were 5,579 active bituminous mines in 1970 of which about three-fourths produced less than 50,000 short tons annually and about one-third produced less than 10,000 short tons (Dept. of the Interior, 1972, part II, p. VI-4). However, the trend in the last years has been toward fewer and larger mines.

The structure of small firms is responsible for the inefficiency of the industry. Henderson (1958, p. 98) writes about coal mining of the U.S. in 1958 the following, and it is relevant, in general terms, to the Colombian case today:

> The failure of the coal industry to reduce its high-cost capacities is largely attributable to its organization, or lack of organization. It is composed of a large number of small firms... The coal industry's position is quite different from that of industries which are controlled by a small number of large firms. The organization of the coal industry is far more like that of agriculture than the other mineral industries.

The decline of coal mining in Western Europe may be explained, among other factors, by an excessive fragmentation of the industry and an irrational system of mining (Mining Jour., 1972b., p. 435).

The Colombian government has to intervene directly in solving this difficult problem. Two possible ways of action that could help to solve partially the situation are:

(1) The big companies could meet the demand of the local market by mechanization and expansion of their operations. The small and medium size coal mines will be phased out. This is a technical solution, but the displaced workmen would then become a social problem for the government.

(2) Merging of the medium-size operations to constitute bigger units and of small-size mines by cooperatives may be the best solution for the problem. "Engineering enterprises and especially mining, require cooperative effort" to achieve success (Hoover, 1938, p. 225).

At the present time the Colombian coal industry employs about 16,000 people. This labor force largely exceeds the current needs of the industry; it illustrates a clear case of "disguised unemployment", most of it in the small and the medium size mines. Even if we accept the 1980 high estimate for total demands for Colombian coal (11,200 M short tons), this output level could be achieved with an employment level of only 8,000 to 10,000 workers. The surplus of coal miners (almost 50 percent) would then have to be relocated to other constructive activities. Coal mining is not the kind of industry that is profitable with intensive-labor operations, not even in developing countries with a high level of unemployment.

Financing

The financing of joint ventures will be provided by the foreign firm or firms and by the national partner from its domestic resources of from international financing agencies such as the World Bank, the Inter-American Development Bank, the Export-Import Bank of the U.S., the European Investment Bank, etc.

This form of financing implies a big sacrifice for the host country and has its limits. This is a reason to suggest that Colombia must begin the participation in a joint venture with the minimum percentage acceptable by the country's foreign investment regulations. The timing for ownerships of 51 percent of the joint venture ought to be renegotiated within the Andean Group to extend it possibly up to 20 to 25 years for mining projects.

Colombia has to take into account that it has possibilities to develop more than one mining coal project, plus other mineral ones (nickel in progress, copper, etc.), that the mining industry is a highly capital-intensive one, and that it has other industries and infrastructure to finance.

The big national firms have access to the normal means of financing: banks, national corporations for development, some public organizations through mixed enterprises, and even international financing agencies through guaranties by the government.

The medium and small-size mines have many financing difficulties. The Minister of Mines and Petroleum dictated Resolution 002904 in 1971 to regulate cash loans to the small and medium mines. The Resolution considers small-size mines as those with an annual gross value of the output of up to Col $600,000 (about U.S. $27,500), and medium mines with a gross value over Col $600,000 and up to Col $2,000,000 (about U.S. $91,000). The loans are up to Col $300,000 (about U.S. $13,600); they are not provided for exploration work, even though it is the most important phase, yet also the most risky one (Boletin de Minas, 1971, p. 7). The amount of these loans is too small to allow development of a technical and semi-mechanized mining industry. In addition, the management of that credit policy is quite complicated. It may be better to provide equipment instead of cash, buying well-selected used equipment in developed countries. If a given operation fails, equipment is easier to recover than cash. However, it is not desirable, in the particular case of coal mining, to encourage additional medium and small-size operations. The existing mechanisms, such as credit and technical assistance, must be used to help solving some of the problems facing these medium and small size firms.

Research.

It is recognized by modern economic theory that technological innovation originating from research is as an important factor in the production function as the traditional factors of capital, labor, and raw materials (Sabato, 1969, p. 52).

What kind of research could Colombia undertake in the field of coal? Clearly the country is not prepared to make the kind of coal research carried on by the U.S., Western Europe or even Poland in this field. The first step in this way is an imitative research, so to speak, of the developed countries that is intended mainly to adapt imported technology to the local circumstances. The joint venture with qualified foreign firms is a good instrument to reach this goal. The government has to encourage and support research through its specialized organizations. If the country does not utilize the joint venture system to learn and to adapt modern techniques, it may be missing the opportunity to derive the utmost from very complex and beneficial contracts under the new regulations of foreign investment.

The following are specific points where coal research is desirable in Colombia:

(1) Preliminary economic evaluation of basins, taking into account their location with respect to local and international markets.

(2) Preliminary exploration of the most favorable areas in order to determine reserves, coal quality, and coal types. These studies are necessary to attract foreign investors.

(3) Classification of coal reserves recoverable by strip or underground mining methods.

(4) Chemical and petrological studies of coal seams and their potential end-use.

(5) Detailed marketing studies at the domestic and international level to determine the requirements of consumers.

(6) Study of the different alternatives proposed by foreign companies to provide sound information to the decision makers. The analysis of the technical capabilities of the firm is relevant because a decision must not only be based on economic factors.

(7) Study of domestic materials that can be used more economically than imported ones in mining and preparation of coal.

(8) The use and promotion of coal as a substitute for other materials. For example, most of the peasants and villagers utilize charcoal or firewood for fuel. A good

investigation would be to determine the areas where coal could compete with the mentioned fuels.

(9) Design of appropriate methods of exploitation for medium and small-size operations.

(10) Blending properties of Colombian coals for coking purposes. Characteristics of the same coals for use as steam fuel.

This list could be longer but it is sufficient to demonstrate the need for preliminary coal research. Many of these points may not be considered research in developed countries, but they are for Colombia where the industry is just starting to develop.

The success of this program depends on the availability of skilled people in the multiple branches of coal science. How to get them? First, attracting qualified scientists by offering them attractive job contracts. Western Europe is maybe the indicated region to look for them, given that the coal industry there is in a declining process in recent years. Second, send Colombian personnel to developed countries to acquire knowledge in specific branches of coal science. Adequate jobs and renumeration must be provided them when they come back to avoid brain drain.

Colombia has to follow closely the research on Western Canadian, Western U.S., and Australian coals that are also geologically young, as is Colombian coal.

The Universities and organizations of the public sector related to coal programs, must have facilities to get technical publications on this subject from all over the world and to translate them into Spanish. Thus, Colombian professionals will be able to follow the advances of coal science and the direction of the research work done within the country and abroad.

SUMMARY AND CONCLUSIONS

This study has been characterized by two very definite parts: the international one involving Latin America and other markets, and the Colombian one. This summary and conclusions chapter is also presented under the same two headings.

International

The examination of the international market has led to the following important points:

-There are two primary coal importing countries or areas in the Free World: Japan and Western Europe, the first being the leading coal importer in the world. Of secondary importance as a coal importer is Canada (Eastern), the only supplier of which is the U.S.

-There are only minor coal importing areas in the underdeveloped nations of the world. The only relevant area for this study is that involving the Latin American countries that have joined the LAFTA and Andean trade agreements.

-A form of captive market is the predominant trend in the international coal trade today, characterized by long term contracts between supplier and consumer countries. This is a negative aspect for a potential new exporter.

-The trend is also not to depend on only few suppliers. The reasons for this is commercial in some cases and safety in others. This factor offsets the negative aspects of the previous point.

-The world demand is mainly for (1) coking bituminous coals or for blending coals to obtain metallurgical coke, (2) high quality steam coals (low ash, low sulfur) to meet the environmental requirements of the developed countries. In the long run the demand for steam coals will increase, given that poor countries and even some of the developed ones will not be able to meet their energy needs by nuclear and other nonconventional sources of energy due to lack of know-how and immense investment. Besides, the price differential between petroleum or gas and coal will be larger in the foreseeable future, as oil and gas reserves are less abundant and most of them are found in regions of uncertain political stability.

Colombia

Colombia has most of the estimated coal resources of Latin America but so far the country has not received any economic benefit from that wealth. The coals are young geologically and present sharp variations in the same coalfield.

The main coal resources are found in the Departments of Boyaca, Cundinamarca, Valle, Antioquia, Santander, and Guajira. All coal ranks are found, but bituminous predominates. There are some coking coal reserves estimated at 3 million metric tons (table 2).

Fifty to sixty percent of the total coal output comes from 6 big semi-mechanized and well-organized companies. The remainder is produced by small-size mines, with primitive mining methods and tools. An oversupply situation predominates in the local market. Big mines are generally captive; medium and small-size mines depend totally on the consumers. This is one of the decisive factors influencing the low prices that exist in the domestic market.

The primitive part of the coal industry does not provide any profit, either to the miners who live in an underemployment situation or to the country which is harmed by the destruction of this natural resource. The government has to deny new exploitation permits for these operations, using the instruments provided by law. At the same time, the available mechanisms (technical assistance and credit) must be put into use for solving this sector's problems. It is advisable, for example, to stimulate merger movements among small mines. Control of programs and mining plans of the larger national companies are also necessary to

guarantee a rational exploitation of the resource.

The present structure of Colombian coal mining is not appropriate to develop a competitive export trade, because it is not sufficiently capital-intensive. Past failures were due mainly to the fact that this factor was not considered. Thus, the joint international venture seems to be the most advisable organization form to be successful in coal exports, in accordance with the latest rules on foreign investment. It would be formed by foreign firms of the developed countries, with broad experience covering exploration to marketing of coal, and Colombian government and/or Andean private or public organizations. At first, the operations will be undertaken by the foreign firm(s) to prevent political factors from interfering with technical and commercial considerations. This situation will last until the national personnel have the necessary skills to handle these operations efficiently.

A preliminary market study and forecasts showed the following output estimates for Colombia in 1980: Low 4,120 M short tons, most likely 4,530 M short tons, high 11,200 M short tons. The high figure includes the estimated value for exports, assuming that Colombia captures 50 percent of Latin American market (about 4,670 M short tons) and puts in other markets 2,000 M short tons. To meet this demand each individual mine would produce at least 1 million short

tons annually to utilize high mechanization and economies of scale. Generally, in underdeveloped countries the initial investment for a mining project could reach 2 1/2 to 5 times that of developed ones because of the need to build the infrastructure: main road, hospital, airport, aqueduct, and so on.

Problems and key points in developing Colombian coal mining have been studied, taking into account export markets. Ocean transportation of coal, which could be a bottleneck, can be best solved by the joint venture because the foreign firm is generally a multinational one which can employ a combination trade among its different operations.

A fiscal policy to encourage investment is an important factor if foreign capital is to be attracted. Coal mining, and mining in general, needs special treatment given that it is a high risk business. A Colombian rule on foreign investment which has often been controversial is that limiting the repatriation of profits and dividends to a maximum of 14 percent; fortunately enough, the rule is now negotiable under the special permission of the Commission governing the Andean Pact.

Colombia has first to conduct preliminary geologic and economic studies to attract foreign investors and then to adopt the imported technology to local conditions, before undertaking a more original research. The advantages of partnership with foreign firms are not expressed only in physical profits but also in acquisitions of know-how, training of labor, marketing techniques, and infrastructure development.

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