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An Econometric Model of the Iron Ore Industry

Theophilos Pnovolos

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ABSTRACT

This paper presents a model of the world iron ore industry that uses game theory principles to determine iron ore prices. The boundaries of the range of price negotiations are specified through bilateral oligopolistic theory end are further constrained so that the negotiating parties are not put out of business. The validation of the model indicates that it is suitable for policy analysis as well. Multiplier analysis is used to trace the channels of transmission of exogenous shocks in the iron ore markets. The simulations show that an increase in Brazilian iron ore capacity will reduce iron ore prices and lead to a redistribution of market shares among the producers. Increases in EEC crude steel production and exogenous increases in scrap prices or in the inflation index will tend to increase iron ore prices. The simulations also indicate that depreciation of the U.S. dollar relative to European and Japanese currencies will have a negative effect on iron ore prices in the first eight years and a positive effect in the next two. But the overall effect of the U.S. dollar depreciation is found to be very small over a ten-year period.

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I. INTRODUCTION

Previous efforts to model the iron ore industry were not independent of efforts to model the steel industry. A review of these earlier iron ore and steel studies shows that they focused on estimating the demand for iron ore.1/ In most cases iron ore prices were determined exogenously. In addition, effective capacity, production, exports, imports and apparent consumption of iron ore by country were not explicitly specified; their interrelationships were also not modeled. Furthermore, simplifying generalizations regarding the competitiveness of the industry were usually made.

Chapter II describes some of the unique characteristics of the iron ore industry. It was our objective to build a model that reflects most of these characteristics; a model that simultaneously estimates and specifies prices as well as volumes and that answers a number of pertinent policy questions regarding the state of the industry today. Examples include: the impact of increases in iron ore capacity in Brazil on prices; the impact of changes in the US dollar exchange rate vis-a-vis other currencies on production, consumption and prices of iron ore; the impact of changes in prices of unit factor costs on the iron ore production process or the impact of changes in prices of substitutes to iron ore (such as scrap) on production, consumption and iron ore prices etc.

Chapter III presents the structure of the model. The relative bargaining power of negotiating parties is quantified and game theory principles are used to model the determination of iron ore prices. Chapter IV

1/ For a review of these models see H. Hashimoto, "A World Iron and Steel Economy Model: the WISE Model" in World Bank Commodity Models, World Bank Staff Commodity Working Paper No. 6, June 1981, Washington, D.C.

analyzes the specification of most behavioral equations of the model. Chapter V discusses the validation of the model and shows hov well the dynamic simulation path replicates the historical data. In addition, multiplier analysis is used to answer policy questions and to detail the impact on the iron ore industry of exogenous shocks.

II. THE IRON ORE INDUSTRY

II.1 Background and Definitions

Iron (Fe) is one of the most abundant and most widely distributed elements in the world and probably constitutes upwards of 5% of the earth's weight. It is estimated that world resources of iron ore exceed 800 billion tons of crude ore, containing more than 250 billion tons of iron. The iron-bearing minerals are by far mostly iron silicates. Rarely are these considered "iron ore" because "ore" infers an iron-bearing substance that is an economically viable material. The designation "ore" is dependent on many factors such as location, knowledge of its composition and extent, technology and accessibility. The major forms of iron worldwide, as classified by their chemical composition, are as follows:

(a) Magnetite (Fe_3O_4) which in its pure form contains 72% iron;

(b) Hematite (Fe_2O_3) which when pure contains about 70% iron (hematite is the most common ore of iron);

(c) Taconite containing 15-35% iron;

(d) Limonite, referred to as brown hematite, is a hydrous ferric oxide;

(e) Siderite ($FeCO_3$) containing about 48% iron;

(f) Pyrite (FeS_2) containing 47% iron; and

(g) Pyrrhotite which contains 60% iron,

Iron ore is the source of primary iron for the world's steel industry. In order to produce metallic iron for steel making, it is necessary to mine suitable iron-bearing minerals and treat them through a series of processes. The final process is some form of chemical "reduction" during which a "reducing agent" combines with unwanted chemical elements in the mineral and releases the iron as a metal. More than 90% of the world's present new supply of metallic iron is produced each year as pig iron, from iron ores that are smelted in blast farnaces. Pig iron is defined as a high-carbon iron made by reduction of iron ore in the blast furnace.

Iron ore as mined in its natural state is called crude ore. Crude ore may be merchantable without processing or with minimal processing such as crushing and screening, in which case it is called direct-shipping ore. The final ore product of a mining operation, whether direct-shipping ore or the product of extensive processing, is called usable ore or marketable ore. Usable ore includes lump ore, fines, concentrates and agglomerates. Lump ore consists of particles one-quarter inch or larger. Fines are particles less than one-quarter inch in diameter; sinter feed consists mostly of fines larger than 100 mesh, while fines smaller than 100 mesh may be classed as pellet feed. The products of beneficiation plants are called concentrates and are classified as coarse (plus one-quarter inch) or fine (minus one-quarter inch) as indicated above. Fine concentrates or natural ores are agglomerated to facilitate transportation and smelting; these products are called pellets, sinter, briquets, etc., depending on the agglomerating process used. 1/

According to the US Bureau of Mines' statistics, world iron ore nominal capacity is estimated to be close to 639.6 million metric tons in iron content in 1984. 2/ Of this capacity 17% and 19% are considered to be in North America and South America, respectively, 32% and 8% are considered to be in

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1/ See Bureau of Nines, U.S. Department of the Interior, "Iron Ore," preprint from Bulletin 675, 1985 edition, Washington, D.C.

2/ See Table 1.

Table 1: WORLD IRON ORE CAPACITY - 1983 AND 1984

REGION/COUNTRY	NOMINAL		EFFECTIVE CAPACITY /A	
	1983	1984	1983	1984
	(million metric tons iron content)			
NORTH AMERICA				
CANADA	42.6	41.7	34.5	34.0
UNITED STATES	63.5	58.1	48.7	47.7
SOUTH AMERICA				
BRAZIL	86.3	91.6	67.9	69.0
VENEZUELA	15.4	15.4	7.2	6.2
EUROPE /B				
FRANCE	8.1	8.1	8.1	8.1
SWEDEN	14.5	12.7	16.7	16.4
USSR	164.2	165.1	140.7	142.1
AFRICA				
LIBERIA	13.6	13.6	12.4	11.4
SOUTH AFRICA, REP. OF	22.7	22.7	18.4	18.2
ASIA				
INDIA	30.8	31.7	27.4	27.5
CHINA & OTHER	45.4	45.4	42.3 /C	43.1 /C
OCEANIA				
AUSTRALIA	81.2	79.4	64.4	64.7
WORLD TOTAL	641.4	639.6	544.5	543.1

/A EFFECTIVE CAPACITY IS CALCULATED USING PEAK PRODUCTION RATES. THE EFFECTIVE CAPACITY FIGURES COULD BE INCREASED SUBSTANTIALLY IF MARKET CONDITIONS WARRANTED.

/B INCLUDES CPEs.

/C CHINA ONLY.

SOURCES: NOMINAL CAPACITY FIGURES: BUREAU OF MINES, US DEPARTMENT OF INTERIOR; EFFECTIVE CAPACITY FIGURES: WORLD BANK, INTERNATIONAL ECONOMICS DEPARTMENT.

Europe (including the CPEs) and Africa, respectively, and 12% and 13% are considered to be in Asia and Oceania, respectively. At present, the USSR, Brazil and Australia account for 53% of world nominal capacity or 51% of world effective capacity. The International Iron Ore and Steel Institute (IISI) and the World Bank 1/ project that in the next 15 years, world iron ore capacity will expand by about 37 million tons in Fe content. Brazil, China, Australia, Canada and India are expected to increase their iron ore capacity by about 53 million tons. Other producing countries in Africa, Europe and North America are expected, however, to have their capacity cut as their high-quality, lor cost reserves are depleted.

11.2 Production and Apparent Consumption of Iron Ore

Ninety-five percent of all iron ore production is consumed by the world's steel-making industry. Annual world iron ore production (in actual weight! usually exceeds 800 million tons of which about 90% is produced by 12 countries. World iron ore production in Fe content was 515 million tons in 1985 (see Table 2). The USSR, the United States, France and Sweden were the major iron ore producers in 1960. The combined production of Brazil and Australia accounted for only 2.52 of world production in 1960. Twenty-five years later, Brazil and Australia accounted for close to 25% of world productior.. The United States, Prance and Sweden have, however, seen their combined share of world production fall from 42.5% in 1960 to 9.9% in 1985. Differences in production cost accounted for these changes in the geographical

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1/ See Report 814/86, Price Prospects for Major Primary Commodities, The World Bank, International Economics Department, October 1986.

Table 2: IRON ORE PRODUCTION
(FE CONTENT IN MILLION TONS)

	LEVEL OF PRODUCTION				GROWTH RATE			SHARE OF TOTAL				FERROUS CONTENT	
COUNTRY	1960	1970	1980	1985	1960-85 /A	1960-69 /A	1970-79 /A	1960	1970	1980	1985	1960	1980
					%								
CANADA	10.66	29.50	31.64	23.67	2.7	11.6	2.7	4.23	6.94	5.85	4.59	55.00	61.79
UNITED STATES	48.40	53.81	47.45	29.26	-1.6	2.7	-0.9	19.21	12.66	8.78	5.67	53.65	60.99
FRANCE	22.35	17.94	9.05	4.41	-5.8	-3.3	-7.4	18.10	4.22	1.67	0.86	33.00	31.00
SWEDEN	12.99	19.80	17.67	12.37	-1.1	5.3	-3.9	5.15	4.66	3.27	2.39	59.87	62.00
AUSTRALIA	2.85	32.80	60.14	56.07	14.5	26.8	5.3	1.13	7.72	11.13	10.87	64.05	62.01
LIBERIA	2.19	15.81	11.13	9.83	4.3	28.8	-4.8	0.87	3.72	2.10	1.90	66.99	62.00 /E
MAURITANIA	0.00	5.92	5.20	5.98	7.2 /B	47.5 /C	-1.7	0.00	1.39	0.96	1.16	65.00 /D	65.00
INDIA	10.30	19.45	25.20	26.38	4.4	9.7	2.9	4.09	4.57	4.66	5.11	62.00	63.00
BRAZIL	3.42	24.74	62.22	76.80	11.9	18.8	11.8	1.36	5.82	11.51	14.89	64.99	63.99
CHILE	3.63	6.94	7.46	3.68	-1.4	7.9	-2.1	1.44	1.63	1.38	0.71	60.01	63.57 /E
VENEZUELA	11.90	13.10	10.33	9.56	-0.3	1.8	-5.0	4.72	3.08	1.75	1.85	58.91	63.93
PERU	3.14	6.12	3.82	3.33	-0.6	7.9	-6.8	1.25	1.44	0.71	0.64	59.00	66.96
SOUTH AFRICA	1.84	4.66	18.90	15.37	9.1	13.2	15.2	0.73	1.10	3.65	2.97	59.75	63.00
USSR	63.93	106.06	136.80	136.24	3.1	4.5	2.8	25.38	24.95	25.32	26.42	60.00	54.78
CHINA	16.50	24.20	63.05	72.80	8.0	3.9	4.6	6.55	5.69	11.66	14.11	30.00	56.00
WORLD	251.91	425.10	540.33	515.72	3.2	5.7	1.9	100.00	100.00	100.00	100.00	48.53	58.15

/A ESTIMATED ON THE BASIS OF LEAST SQUARES TREND FITTING.
/B 1961-1983.
/C 1961-1969.
/D IN 1961.
/E IN 1978.

SOURCES: UNCTAD, 1985 YEARBOOK OF INTERNATIONAL COMMODITY STATISTICS, JULY, 1986, GENEVA, AND WORLD BANK ESTIMATES.

location of iron ore mines during the 1960-85 period. Table 3 shows that in 1981, operating costs were substantially lower in Brazil and Australia than, for example, in Liberia or the United States. The World Bank estimates that in terms of investment costs per annual ton of new capacity (gross or actual weight) expansion projects can be costed as low as US$20/ton, whereas replacement projects have capital costs of US$25-75/ton and greenfield projects US$100/ton and above. The level of interest rates can thus greatly affect the profitability of operations in the iron ore industry.

Total costs vary substantially among countries. Brazil and Australia are the lowest cost producers of sinter fines and pellets. Pellet plants are more costly to operate than plants producing sinter finer. Pelletizing is an energy-intensive operation which is directly related to the type of ore being processed. The amount of fuel used when the ore is of the hematite type is 28 liters/ton; when the ore is of the magnetite type it is 15 liters/ton. Table 4 provides details on rail and ocean freight transportation costs. These costs vary enormously between mines and countries. In anticipation of higher iron ore demand and the search for new resources of high-grade ore, the world's ore resources were augmented considerably in the 1960-85 period. Furthermore, the development of improved beneficiating methods made numerous low-grade deposits economically viable in spite of an abundance of higher quality ore. Concurrently with these developments two other important developments profoundly influenced steel production and demand for iron ore.

Foremost was the rapid development of computerized continuous casting techniques and electric arc furnaces (that may use 100% scrap); these techniques increase the output of finished steel from a specific amount of raw steel. The net effect is that less iron ore is now required for the production

Table 3: SINTER FINES PRODUCTION COSTS FOR SELECTED WORLD IRON ORE SURFACE MINES AND DEPOSITS /A

COUNTRY	NO. @ PROPERTIES	ANNUAL CAPACITY (MMT)	ORE GRADE (PCT)	---RATING COSTS--- 1984 US$/LT ORE WINE	RAIL	BENEFICIATION
AFRICA						
PRODUCERS /B	7	2.2-24.6	63-65	1.10-3.40	0.25-15.76 /C	0.60-2.30
NONPRODUCERS /D	12	45 - 25	56-67	1.80-3.20		0.90-3.80
AUSTRALIA						
PRODUCERS	5	2.7-45.0	57-65	1.60-2.60	0.15-1.72	0.30-1.60
NONPRODUCERS	14	9.8-28.0	62-64	1.70-3.60		0.30-0.50
BRAZIL						
PRODUCERS	13	1.5-27.0	65-67	0.70-2.00	3.20-5.11	0.50-1.70
CANADA						
PRODUCERS	3	17.4-43.8	66	2.00-2.50	3.28-4.05	3.00-3.50
EUROPE						
PRODUCERS /E	5	1.3-17.7	50-70	2.60-7.20	6.84-9.24 /F	1.50-4.50
INDIA						
PRODUCERS	5	1.2-20.3	59-67	1.00-5.00	1.20-9.40	0.50-1.50
MEXICO						
PRODUCERS	5	2.0-5.0	60-69	3.70-6.50		1.90-3.00
OTHER SOUTH AMERICA						
PRODUCERS /G	7	3.8-14.8	61-67	1.90-2.4C		0.90-2.70
NONPRODUCERS /H	4	4.5-9.5	62-64	1.90-21.0		W
UNITED STATES						
LAKE SUPERIOR PRODUCERS /I	9	8.2-61.7	63-66	2.00-4.50	0.25-4.80	3.25-5.00
LAKE SUPERIOR NONPRODUCERS /J	12	2.2-28.7	62-65	2.50-4.50		3.50-9.00
O M R NONPRODUCERS /K	20	0.7-8.9	42-69	3.50-15.50		2.00-6.75

NAp = NOT APPLICABLE, W = WITHHELD. LT = LONG TON (EQUAL 1.016 METRIC TON).

/A PRODUCERS INCLUDE PRESENTLY PRODUCING MINES; NONPRODUCERS INCLUDE PAST PRODUCERS, EXPLORED OR DEVELOPING DEPOSITS.

/B AFRICAN PRODUCERS INCLUDE ALGERIA, LIBERIA, MAURITANIA, REPUBLIC OF SOUTH AFRICA AND SIERRA LEONE.

/C SOUTH AFRICA.

/D AFRICAN NONPRODUCERS INCLUDE ALGERIA, CAMEROON, GABON, LIBYA, IVORY COAST, LIBERIA, GUINEA AND MAURITANIA.

/E EUROPEAN PRODUCERS INCLUDE NORWAY, SPAIN AND SWEDEN.

/F SWEDEN.

/G OTHER SOUTH AMERICAN PRODUCERS INCLUDE WILE, PERU AND VENEZUELA.

/H OTHER SOUTH AMERICAN NONPRODUCERS INCLUDE VENEZUELA.

/I LAKE SUPERIOR PRODUCERS INCLUDE MINES IN THE MESABI AND MARQUETTE RANGES.

/J LAKE SUPERIOR NONPRODUCERS INCLUDE MINES AND DEPOSITS IN THE MESABI, MARQUETTE, AND GOGEBIC RANGES.

/K OTHER NONPRODUCERS INCLUDE CALIFORNIA, MISSOURI, MONTANA, NEVADA, NEW JERSEY, NEW YORK, TEXAS, UTAH AND WYOMING.

SOURCE: THE US BUREAU OF MINES, 1987, IRON ORE AVAILABILITY - MARKET ECONOMY COUNTRIES: A MINERALS AVAILABILITY APPRAISAL, BY J.L. BOLIS AND J.A. BEKKALA, WASHINGTON, DC.

Table 4: OPERATING, RAIL AND OCEAN FREIGHT COSTS FOR SINTER FINES AND PELLETS

(1984 US$/LONG TON)

REGION/ COUNTRY	SINTER FINES OPERATING COSTS	PELLETS OPERATING COSTS	RAIL TRANSPORTATION COST	OCEAN FREIGHT COST
BRAZIL				
PRODUCERS	1.2-3.7	12.30-13.00	3.20-5.11	4.50-6.50 /A
CANADA				
PRODUCERS /B	5.0-6.0	15.00-22.70	3.28-4.05	3.00-4.25 /C
EUROPE				
PRODUCERS	4.10-11.7	5.70-8.90	6.84-9.24 /D	1.75-2.30 /E
MEXICO				
PRODUCERS	5.6-9.5	7.50-10.40		
UNITED STATES				
LAKE SUPERIOR PRODUCERS	5.25-9.50	6.00-10.60	0.25-4.80	
LAKE SUPERIOR NONPRODUCERS	6.00-13.50	7.30-12.90	0.25-4.80	
OTHER NONPRODUCERS	5.5-22.25	6.50-14.00	0.25-4.80	

/A TO WESTERN EUROPE.
/B CANADIAN PRODUCERS INCLUDE MINES PROCESSING ONLY HEMATITE ORES.
/C TO WESTERN EUROPE.
/D SWEDEN.
/E FROM NORWAY TO WESTERN EUROPE.

SOURCE: THE US BUREAU OF MINES, 1987, IRON ORE AVAILABILITY - MARKET ECONOMY COUNTRIES: A MINERALS AVAILABILITY APPRAISAL, BY J.L. BOLIS AND J.A. BEKKALA, WASHINGTON, DC.

of one ton of crude steel. About 1.2 tons of iron ore is required per ton of steel using these processes, compared to 1.6 tons for the almost economically-obsolete open hearth furnace systems.

Second, there were important changes in the type of steel being consumed and technological improvements in steel utilization. The use of high-strength steel in the automobile industry led to weight savings and smaller cars. The evolvement of new techniques in building and civil construction permitted greater use of concrete and high-tensile steels. These examples and others, such as the use of substitute materials (e.g., aluminum for steel in automobiles), or improved manufacturing techniques (e.g., in household durables) have led to decreased steel use and ultimately reduced iron ore demand. Partly as a result the growth of iron ore consumption slowed from 5.5% p.a. in the 1960-69 period to 1.8% p.a. in the 1970-79 period; consumption declined by 1.2% p.a. in the 1980-85 period (see Table 5). The development of the steel industry in Japan, Brazil, the Republic of Korea and China coincided with the decline of the steel industry in the United States and the EEC. As a result, the demand for iron ore changed considerably among countries in the 1960-85 period. The share of apparent consumption held by the United Stater declined from 26% in 1960 to 7.3% in 1985. On the other hand, Japan's share increased from 4.12 to 15.1%. The demand for iron ore increased fastest in Japan, Canada, Brazil, the Republic of Korea, India, South Africa, Mexico, China and Spain.

11.3 International Trade

The percentage of wcrld iron ore production traded internationally has rose from 30% in 1961 to 46% in 1985. International trade volume reached a peak of about 234 million tons (in iron content) in 1985.

Table 5: IRON ORE APPARENT CONSUMPTION

(FE CONTENT IN MILLION TONS)

COUNTRY	LEVEL Of APPARENT CONSUMPTION 1960	1970	1980	1985	GROWTH RATE 1960-85 /A	1960-69 /A	1970-79 /A	SHARE ff TOTAL. 1960	1970	1980	1985	FERROUS CONTENT 1960	1980
					(%)								
CANADA	3.95	6.46	11.15	7.05	3.4	-0.9	6.0	1.56	1.53	2.11	1.43	58.63	61.63
UNITED STATES	65.91	78.43	59.38	35.97	-2.0	3.7	-1.4	25.95	18.57	11.29	7.28	54.93	60.92
GERMANY, F.R.	22.51	29.60	29.50	26.37	1.0	2.1	-0.3	8.86	7.10	5.61	5.34	43.15	56.97
FRANCE	14.97	18.31	17.74	12.87	-0.1	0.2	-1.4	5.89	4.34	3.37	2.60	35.58	45.27
BELGIUM-LUX.	9.20	15.02	10.36	8.36	-0.5	4.9	-3.1	3.62	3.56	1.97	1.69	33.20	45.57
SWEDEN	1.21	2.82	4.65	1.24	-2.8	5.5	-26.0	0.48	0.67	0.88	0.25	61.36	61.99
SPAIN	2.12	3.95	6.95	5.61	5.5	2.6	5.0	0.83	0.94	1.32	1.35	50.05	59.70
UNITED KINGDOM	15.18	16.22	5.44	9.49	-2.5	0.8	-3.6	5.98	3.84	1.03	1.92	43.40	57.60
JAPAN	10.30	64.05	80.62	74.88	7.8	18.8	1.2	4.05	15.17	15.32	15.13	58.73	60.07
AUSTRALIA	2.98	6.49	8.95	2.09 E	1.0	10.8	-2.2	1.17	1.54	1.70	0.43	62.92	53.78
SOUTH M RICA	1.59	2.69	8.17	8.94	6.2	10.1	9.9	0.63	0.64	1.55	1.81	59.40	57.92
INDIA	4.67	6.30	9.84	7.95	4.5	15.8	6.4	1.84	1.49	1.87	1.61	62.47	64.63
BRAZIL	1.95 /B	6.14	8.53	13.11	5.3 /C	17.4 /D	11.9	0.81 /B	1.45	1.62	2.65	63.00 /B	46.65
MEXICO	1.15 /B	2.73	4.07	5.89	7.4 /C	8.4 /D	3.9	0.47/ B	0.65	0.77	1.19	64.16 /B	61.67
USSR	56.33	86.20	111.56	112.98	2.8	3.5	3.2	22.17	20.41	21.20	22.83	61.65	54.92
CZECHOSLOVAKIA	5.19	7.65	7.85	7.20 E	1.8	2.4	2.8	2.04	1.81	1.49	1.45	50.23	53.20
CHINA	16.50	24.20	66.60	77.84	8.2	3.9	5.7	6.50	5.73	8.29	15.73	30.00	56.50
WORLD	254.01	422.38	526.11	494.94 E	3.0	5.5	1.8	100.00	100.00	100.00	100.00	48.67	56.46

/A ESTIMATED ON THE BAS S Of LEAST SQUARES TREND FITTING.
/B 1961.
/C 1960-1983.
/D 1960-1969.
/E ESTIMATED.

SOURCES: UNCTAD, 1985 YEARBOOK OF INTERNATIONAL COMMODITY STATISTICS, JULY, 1986, GENEVA, AND WORLD BANK ESTIMATES.

In 1985, six countries accounted for more than 75% of iron ore exports. Three groups, Japan, the EEC and the United States, consumed about 70% of the iron ore traded on the international market (see Table 6). 1/

The Japanese steel industry is based on imported ore because there are virtually no domestic iron ore resources. The Western European steel industry was established on the basis of domestic ores. Due to the present marginal quality of these ores, with grades between 30–40% iron, and the associated increased costs for pig-iron production, the EEC countries now import about 80% of their iron ore requirements.

There are a number of distinct differences betveen industrial and developing countries with respect to iron ore trade. As an example, in 1975, developing countries furnished 95% of their exports to the industrial countries. This constituted almost SOX of the total import needs of iron ore of the industrial countries. The developing countries are generally located farther avay from their markets than are the industrial countries which export iron ore,

Developing countries, however, have increased steel production rapidly, as reflected in the 5.7 p.a. increase in iron ore consumption during the 1970s. In contrast, the consumption of iron ore in the industrial countries decreased at an annual rate of 0.7% during the same period.

Long–term contracts cover the major part of all iron ore transactions between the steel mills and their captive mines as well as between the iron ore producers and steel mills in general. At present, the Japanese steel industry meets 90% of its import requirements under this type of arrangement,

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1/ Exports are presented in Table 6 in terms of iron ore content.

Table 6: IRON ORE EXPORTS
(FE CONTENT IN MILLION TONS)

COUNTRY	LEVEL OF EXPORTS 1960	1970	1980	1985	GROWTH RATE 1960-85 /A	1960-69 /A	1970-79 /A	SHARE OF TOTAL 1960	1970	1980	1985	FERROUS CONTENT 1960	1980
					(%)								
CANADA	9.20	24.40	24.13	20.21	2.3	11.2	2.4	11.52	12.75	10.02	8.60	53.43	61.89
UNITED STATES	2.89	3.29	3.60	3.07	-1.5	1.9	1.8	3.62	1.72	1.49	1.31	53.99	62.14
FRANCE	8.24	5.59	2.68	1.44	-6.4	-4.6	-6.8	10.36	2.92	1.11	0.61	30.33	31.00
SWEDEN	11.77	17.06	13.02	11.17	-1.0	5.0	-2.9	14.79	8.91	5.41	4.75	59.72	62.00
AUSTRALIA	0.00	26.31	51.21	54.01	26.7 /B	252.0 /C	6.3	0.00	13.74	21.27	22.99	60.00 /D	63.71
SOUTH AFRICA	0.25	1.97	10.73	6.43	16.4	26.5	22.1	0.31	1.03	4.46	2.74	62.18	67.30
LIBERIA	2.02	14.16	11.70	10.79	5.5	26.8	-0.3	2.52	7.40	4.86	4.59	68.01	68.00
MAURITANIA	0.00	5.81	5.67	6.05	3.4 /E	27.2 /F	-0.9	0.00	3.03	2.36	2.57	63.03 /G	65.21
INDIA	5.63	13.15	15.36	18.43	4.6	6.5	0.5	7.05	6.87	6.37	7.85	62.00	62.00
BRAZIL	3.67	18.60	53.69	63.69	13.1	14.5	12.6	4.59	9.72	22.30	27.11	70.00	68.00
CHILE	3.32	6.14	5.22	3.26	-15.1	7.3	-1.7	4.16	3.21	2.16	1.39	64.00	68.80
VENEZUELA	11.30	12.50	7.35	5.76	-2.2	1.3	-5.2	14.16	6.53	3.05	2.45	58.55	62.66
USSR	7.60	19.86	24.84	23.26	4.4	10.3	0.7	9.52	10.38	10.32	9.90	50.06	54.00
PERU	3.10	6.00	2.83	3.56	-0.9	7.9	-7.4	3.89	3.13	1.18	1.52	59.99	67.00
WORLD	79.83	191.42	240.74	234.90	4.6	9.0	2.5	100.00	100.00	100.00	100.00	52.54	62.69

/A ESTIMATED ON THE BASIS OF LEAST SQUARES TRENO FITTING,
/B 1965-1983.
/C 1965-1969.
/D IN 1965.
/E 1963-1983.
/F 1963-1969.
/G IN 1963.

SOURCES: UNCTAD, 1985 YEARBOOK OF INTERNATIONAL COMMODITY STATISTICS, *JULY, 1986*, GENEVA, AND WORLD BANK ESTIMATES.

whereas the European countries receive 40% of their imports under long-tern contracts. The balance represents sales on the spot market or under short-term contracts.

The steel producers have established very close relationships with most iron ore mines that began producing in the early 1960s. Examples include mines in Canada and Western Africa which have partial ownership by steel companies, and the nines in Australia which vere established under long-term contracts to Japanese steel mills. These relationships assure the steel producers of a stable source and price for their ore. In the last decade, large consumers have reduced their supply risk further through direct investment in additional mines and/or long-term contracts with other mines, resulting in a diversification of sources for iron ore. In addition, buyers have assured themselves of a more-than-adequate supply of iron ore by offering incentives to open new mines with long-term contracts or with partial ownership. Alternatively, such guaranteed markets are necessary for the mine owners and their financial backers to justify the large investments needed to develop the mines.

In the past, under the umbrella of long-term supply contracts, the iron ore industry and trade develop along a fairly stable growth past. However, in recent years, a gradual reduction of the stability provided by these long-term arrangements has been witnessed. The breach of contracted basic quantity commitments has become more the norm rather than their fulfillment. In many cases, steel mills have accepted only 60%-70%of basic contractual tonnages, making the usual 10% quantity variation clauses appear meaningless.

This contractual breakdown has increased the tendency towards wider quantity margins and shorter contract durations. Persistence of this trend, coupled with the apparent latitude in approach to the quantity margins, vill greatly diminish the value of these contracts and can only result in increased competitiveness in iron ore mining operations and in the shipping industry operations.

II.4 Price Structure

Iron ore presently accounts for only 10-15% of the cost of a ton of steel even though it takes about 1.2 tons of iron ore to produce one ton of steel. The price of iron ore does not fluctuate automatically with the price of iron/steel.

The market for iron ore is essentially a bilateral oligopolistic market, with relatively few producers selling their product to relatively few buyers, On the demand side, Japanese and European steel makers dominate the market for iron ore, and, to a great extent, control iron ore prices. However, individual steel makers normally do not negotiate their own contracts: most negotiations are done through industry-oriented buying organizations. The majority of Japanese purchases and shipping contracts are handled concurrently by the buying companies. The Federal Republic of Germany has two cooperating agencies that are commissioned with the buying and transporting of raw materials for the steel industry, In the United Kingdom and Italy, purchares of iron ore are negotiated horizontally by industry-owned organizations.

Because of their geographic and ownership relationships, Australia is the producer leader for ore imports into Japan, and Brazil (previously it was Sweden) is the producer leader for iron ore imported into Western Europe.

Host iron ore is sold on an annual or multi-year term contract on a tonnage basis, vith an annual or sometimes semi-annual renegotiation of prices. These annual negotiations have a wide impact on the iron ore industry; prices that are negotiated yearly by Brazil and Australia, the largest exporters, are construed as the benchmark prices for the other are exp. ters and consumers during their negotiations.

Steel mills are involved in the development of many iron ore mines either through vertical integration, partial ownership, or through financial and technical assistance. Many of the contracts are intercompany transactions; traditionally, the supply of iron ore to the steel industry in the United States and Canada has been from captive mines. US steel companies continue to invest in ore production facilities and derive up to 80% of their requirements through such transactions. The European steel industry has similar ownership ties with mines in West Africa and Latin America. However, several of the mines in these regions have been nationalized and the supply of ore through these ties has been significantly reduced.

Iron ore is not a homogenous commodity with respect to contained iron, size, or deleterious material. Consequently, the price structure is complex; sales of the different qualities of ores require a vast range of prices to account for these quality differences.

The price for iron ore paid to the mine, with the exception of domestic ores, is the calculated FOB price. However, the FOB price is derived from the CIF price which is the price with which the steel producerr are initially concerned. CIF or C+P prices for fully comparable products tend to be equal in a given market. This is because iron ore buyers will generally negotiate contracts so that prices for iron ore of the same quality are all equal on a delivered basis. The FOB price is determined by subtracting the estimated ocean freight cost from the CIP price. The resulting FOB price is used as a basis for reimbursement to the mine. Differences in CIP prices between various iron ores delivered to a particular steel mill are, therefore, due either to differences in quality or type of the ore or to differences in the type of contract and date of its negotiation.

Basing the sale price of iron ore on the FOB value has made the steel mills responsible for paying ocean freight costs and for price fluctuationr in freight rates. Steel producers prefer to be responsible for ocean freight costs; indeed, it has been difficult for iron ore producers to negotiate contracts in which they are responsible for shipping arrangements. Since ocean freight rates have been steadily declining for the past two decades, the steel producers, not the iron ore producers, have benefitted from reduced rater though some of the benefit must accrue to the exporters. Although the buyers benefit from the reduction in transport costs, the exporters invest the capital for the port facilities that have made the lower ocean transport costs possible through accommodating larger vessels.

The increased abundance of iron ore worldwide, over time, has placed the producers at a greater disadvantage during price negotiations. The oversupply of iron ore capacity in the last decade has made the market increasingly competitive and has contributed significantly to declining international prices in real terms. Increasingly stringent conditions have been imposed upon the ore producers by the steel makers. Although steel companies have diversified their markets while at the same time diversifying their iron ore supplies, iron ore exporters have not been successful in diversifying their markets (see Table 7). Each of the major exporting countries rely mainly on one market, which weakens their position with respect to the other potential buyers. Examples of this dependency in exports are Canada to the United States, Sweden Lo Western Europe and Australia to Japan. The formation of the Association of Iron Ore Exporting Countries (APEF) has only marginally improved the negotiating posture of the iron ore producers. It has not been very effective since both Brazil and Canada have opted not to join. 1/

Although the determination of prices during the contractual negotiations remains rather complex, some basic r 'anisms have been established and in general applied through the years. Up to a few years ago, the annual European iron ore price negotiations normally started in October/November and ended before Christmas. 2/ In some recent years the negotiations have had a tendency to drag on well into the new year. In cases where no price agreement had been reached before the end of the delivery year, the parties normally agreed on a provisional price for shipments in the new year. In view of the large ore quantities received via Rotterdam, it has for very many years been the practice to take the CI? Rotterdam price as a reference price for negotiations in Europe. The prices for iron ore delivered

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1/ The APEP was formed in 1975 and consists of Algeria, Australia, Chile, India, Liberia, Mauritania, Peru: Sierra Leone, Sweden, Tunisia and Venezuela. The stated purpose of the APEF is to improve information, marketing cooperation, and to obtain more satisfactory pricing policies for iron ore.

2/ In Europe the "iron ore year" is the calendar year whereas in Japan it is the fiscal year (April 1 to March 31).

Table 7: WORLD TRADE OF IRON ORE BY AREA OF ORIGIN, 1984

(million tons, actual weight)

EXPORTS	IMPORTS: WORLD	DEVELOPING COUNTRIES	INDUSTRIAL COUNTRIES	USA	JAPAN	EEC	OTHER INDUSTRIAL COUNTRIES	EASTERN EUROPE	OTHER COUNTRIES
WORLD	358.7	22.4	278.9	17.4	125.4	118.8	17.3	53.9	3.5
DEVELOPING COUNTRIES	57.6	13.0	132.3	6.0	55.9	64.4	6.0	11.8	0.5
BRAZIL	85.1	8.0	69.9	2.6	29.0	34.4	3.9	6.7	0.5
CHILE	5.0	-	5.0	-	5.0	-	-	-	-
INDIA	24.2	3.4	16.4	-	15.8	0.6	-	4.4	-
LIBERIA	16.2	-	15.7	1.8	0.3	13.2	0.4	0.5	-
MAURITANIA	9.0	-	9.0	-	0.3	8.4	0.3	-	-
PERU	3.8	1.6	2.2	-	1.5	0.4	0.3	-	-
VENMLA	8.3	-	8.3	1.6	-	6.0	0.7	-	-
OTHERS	6.0	-	5.8	-	4.0	1.4	0.4	0.2	-
INDUSTRIAL COUNTRIES	158.2	9.4	144.5	11.4	69.5	54.3	9.3	1.3	3.0
AUSTRALIA	86.0	8.5	74.5	-	58.4	15.6	0.5	-	3.0
CANADA	29.2	-	29.2	11.3	3.1	13.5	1.3	-	-
EEC	4.5	-	4.5	-	-	4.5	-	-	-
SWEDEN	14.5	0.5	13.0	0.1	-	10.9	2.0	1.0	-
OTHERS	24.0	0.4	23.3	-	8.0	9.8	5.5	0.3	-
EASTERN EUROPE AND USSR	42.9	-	2.1	-	-	0.1	2.0	40.8	-

SOURCE: THE WORLD BANK, INTERNATIONAL ECONOMICS DEPARTMENT.

to small European ports have been determined in relation to CIF price Rotterdam after taking into account sea freight and port cost differences between Rotterdam and the port in question.

Up to 1974-75 the CIF Rotterdam reference price was decided in negotiations between the Swedish iron ore sellers and the steel mills of the Federal Republic of Germany. In subsequent years, this reference price was negotiated between the same steel mills and the Brazilian company CVRD. The price is defined in US$ per Fe unit/DMT (dry metric ton). The price differentials for ore quality differences are expressed as premia or discounts on the calculated general FOB price in US¢/Fe unit. 1/

In Japan, price is defined in US$ per Fe unit/DLT (dry long ton). 2/ In the past, Japanese steel mills agreed to pay for "Atlantic" Basin ores the FOB price valid for delivery to European buyers, plus the freight for transport to Japan. As the expansion of steel capacity slowed down in Japan, Japanese steel mills felt more secure in their supplies of iron ore. The pricing policy was gradually replaced by a "freight sharing" system under which the seller and the buyer shared the difference between the freight costs to Europe and Japan on an equal basis. Japanese steel mills now seem to be inclined to change this "freight sharing" system and to follow the European system with equal CIF prices for the various imported iron ores. In view of the oversupply and the relative simplicity of replacing one source of supply

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1/ Iron ore products are sold on an "iron unit basis." For example, a concentrate of 66% contains 66 iron units.

2/ One long ton = 1.016 metric ton.

with another, iron ore markets have become quite competitive and increasingly iron ore is traded on a spot basis.

II.5 Government Role

In many of the producing countries, governments fully or partially own iron ore plants. Brazil, Chile, France, India, Liberia, Mauritania, Mexico, Norway, Peru, Sierra Leone, South Africa, Sweden and Venezuela are some of the countrice where this occurs. Iron ore is a major source of foreign exchange and an important source of tax revenue for many countries.

In view of the perceived economic and strategic importance of the iron ore industry through its link to the steel industry, governments often choose to protect and intervene in its operations, particularly in periods of restructuring and change such as at present. Governmental interventions appear in many forms. For example, the Swedish iron ore mines, which have been in serious financial trouble for a number of years, are being supported by the Government through monetary payouts. Sydvaranger, a Norwegian iron ore company, has been receiving grants from the Government for the past few years. In France, most iron ore mines are assisted by the Covernment, based on the rationale of ensuring a supply of feedstock for the domestic steel industry and to provide employment. The Peruvian Covernment, in the latter part of 1980, provided export tax relief on sales by granting exemption from the 17.5% export tax.

Trade in iron ore benefits from duty-free treatment under two major preterence systems. First, there is the generalized system of preferences (GSP) which has suspended tariff barriers for imports from developing countries in individual country preferential schemes. Second, the special preferences offered by the EEC to African, Caribbean and Pacific (ACP) States under the Lomé Convention which accords duty-free treatment to some primary and industrial prcducts including iron ore. Nontariff barriers are relatively few and generally apply to steel products rather than iron ore. Scch nontariff barriers include import licenses, surcharges, valuation procedures, customs fees and deposits. 1/ At present such interventions are sporadic and limited to very few countries.

1/ See United Nations, "The Iron Ore and Steel Industry," TD/B/6.2/176/Rev.1, Sales No. E.78.II.D.1, 1978, New York.

III. MODEL STRUCTURE

III.1 An Overview of the Main Features of the Model

For a very long time the negotiated price between representatives of Swedish and later Brazilian iron ore companies and representatives of steel mills of Continental Europe (mainly of the Federal Republic of Germany) has been considered the general reference iron ore price on the basis of which other iron ore and steel producers negotiated their contracts. Over the last few years, however, competition has increased. Consumers and small producers have started to negotiate prices and quantities before the conclusion of the negotiations between the representatives of Continental Europe and Brazil. The aim of consumers in doing so is to influence the outcome of negotiations with Brazil, Australia and other major producers, whereas the aim of small producers is to lock in their share of exports early in the year. In the past, based on the principle of equal treatment for all customers, Japanese steel mills succeeded in securing agreement on price changes with Brazilian and Australian suppliers similar to those negotiated between Continental Europe and Brazil. In the future, however, Japanese steel mills are expected to act more independently while taking into consideration the outcome of negotiations between Brazil and Continental Europe.

We will assume here that for all practical purposes the general reference iron ore price (the CIF North Sea for Brazilian 65% Fe sinter fines) is being negotiated and set between representatives of Brazil and Continental

Europe. 1/ This reference price is assumed to affect the negotiations of all other iron ore prices (in a nonhomogenous way). Under these negotiations we assume that market participants recognize their mutual interdependence and reach mutually satisfactory agreement (contract) as to the reference price and the quantity that Brazil will export to most EEC countries (namely, the Federal Republic of Germany, France, United Kingdom, Italy, Belgium, Luxembourg and the Netherlands).

The procers of setting prices and quantities is reparated into two steps. The first step is the preparation for the negotiations by the two parties. During this rtep, the iron ore producers and steel mills specify their desired price and quantity levels and their negotiating strategies independently of each other. The second step involves the bargaining process. It is assumed that the participants negotiate the distribution of their joint profits vith the common objective of agreeing on a price that will not put either participant out of business.

The preparation for negotiation by Brazilian iron ore producers involves estimating the price and quantity of iron ore that will maximize their profits. The producers know well the demand for their products and the cost implications of their operations. To satisfy the first-order condition of the profit maximization problem, the iron ore producers will have to equate marginal revenue with marginal cost. The solution of this problem (which is

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1/ The logic that applies in the determination of iron ore prices between Brazil and Continental Europe may be also applied to other iron ore contractual negotiations, such as negotiations between Brazil and Japan, Australia and Japan, etc.

that of a discriminating monopolist) will provide a price and a quantity for each market that will maximize iron ore producers' profits.

The pre-negotiation preparation by Continental Europe's steel mills is assumed to be similar to that of Brazil. It involves estimating the price and quantity of iron ore that will minimize their cost of production or that will maximize their profits from operating the mills. The steel producers know well their production and cost functions. The first order condition of the profit maximization problem involves equating marginal revenue with respect to iron ore with the marginal cost. The solution of this problem (which is that of a discriminating monopsonist) will provide a price and quantity of iron ore for each market that maximizes the profits of the steel producers.

Both participants in the negotiations know that their desired price and quantity maximize their own profit but not the profit of the other party. During the negotiations they will apply their bargaining power in order to achieve an outcome (i.e., a set of price and quantity) as favorable as possible to their operations. The participants agree first on the quantity to be traded. Usually the allotment is greater than the actual traded quantity. The agreed quantity is not binding on either party. The existence of a spot market makes the quantities of iron ore competitively determined. Moreover, the competitive determination of the output results from the theory of bilateral monopoly and the analysis of the collusion and bargaining process of negotiating parties. 1/ Under this theory, the participants first negotiate a

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1/ The analysis here follows that of J. Henderson and R. Quandt, Microeconomic Theory, McGraw Hill, New York, 1971, pp 244-249. The same notation is used here as in Henderson and Quandt.

quantity thar maximizer their joint profit and they determine a price that distributes their joint profit among them.

The buyer (i.e., the steel producer) uses q_2 (i.e., iron ore) as an input to produce q_1 (i.e., steel) according to his production function $q_1 = h(q_2)$. He sells the steel q_1 at the fixed price p_1. The seller (i.e., the iron ore producer) uses a single input x for the production of q_2. He buys x at the fixed price r. We assume that his production function can be expressed in inverse form as $x = H(q_2)$.

The joint profit of the buyer and reller then would be:

$$\pi = \pi_b + \pi_s = [p_1\, h(q_2) - p_2 q_2] + [p_2 q_2 - rH(q_2)]$$

$$= p_1\, h\,(q_2) - rH(q_2)$$

where π = joint profit

π_b = profit of buyer (steel producer)

π_s = profit of reller (iron ore producer)

setting $d\pi/dq_2$ equal to zero

$$\frac{d\pi}{dq_2} = p_1\, h'\,(q_2) - r\, H'\,(q_2) = 0$$

and

$$p_1\, h'\,(q_2) = r\, H'\,(q_2) \qquad (1)$$

Joint profit is maximized at an output at which the value of the buyer's marginal product equals the seller's marginal coat. This is the same solution as the competitive solution, i.e., as if both buyers and sellers were price takers. Thus we may conclude that the optimal bargaining output level ir the same as the competitive output level of q_2^*. The bargaining solution of the bilateral monopoly does not lead, however, to the competitive price.

As noted earlier, for the prescribed iron ore supply (q_2^*) the iron ore producer desires as high a price as possible and the buyer desires as low a price as possible. Thus, if the upper limit of the price is the price that would force the rteel producer's profit to zero and the lover limit is the price that vould force the iron ore producer's profit to zero we would have:

$$\frac{p_1 h(q_2^*)}{q_2^*} \ge p_2 \ge \frac{rH(q_2^*)}{q_2^*} \qquad (2)$$

Since a negative profit would force one of the parties to discontinue operationr, the price cannot be set beyond there limits if the operationr of the buyer or the seller are not supported otherwise. An alternative is to assume that the steel producer can do no worse than the monopoly solution, and that the iron ore producer can do no worse than the monopsony solution i.e.,

$$p_1 h(q_2^*) - p_2 q_2^* \ge \pi^*_{BS}$$

$$p_2 q_2^* - rH(q_2^*) \ge \pi^*_{SB}$$

solving each inequality for p_2

$$\frac{p_1 h(q_2^*) - \pi^*_{BS}}{q_2^*} \geq p_2 \geq \frac{rH(q_2^*) + \pi^*_{SB}}{q_2^*} \qquad (3)$$

If π^*_{BS} (profit of the buyer when q_2^* is used) and π^*_{SB} (profit of the seller when q_2 is produced) are positive then (3) provides a narrower range for bargaining than (2). In either case the determination of a specific price within the bargaining limits will depend upon the relative bargaining power of the iron ore supplier and the steel consumer. Nash, Shapley and particularly Harsanyi 1/ (who generalizes the Shapley approach to an n-person game without transferable utility) derive equilibrium solutions that are functions of the fixed point (i.e., here the two ranges), the set of weights and strategies and the associated payoffs. A similar approach is used here to determine iron ore pricer within the bargaining limits (2) or (3) and the derived prices from the solution of the problem of discriminating monopolist and of discriminating monopsonist. 2/

We allow the two "players", i.e., the buyer and the seller of iron ore to select their strategies on a probabilistic basis and we let $r_i, \ldots, r_m$ be the probabilities with which the seller will employ each of his m strategies where $0 \leq r_i \leq 1$ $(i=1, \ldots, m)$ and $\sum_{i=1}^{m} r_i = 1$. The buyer can randomize his strategy selection of assigning the probabilities $s_j, \ldots, s_n$ to his strategies, where $0 \leq s_j \leq 1$ $(j=1, \ldots n)$ d $\sum_{j=1}^{n} s_j = 1$. The two players are then concerned with expected returns. The return to the seller will be equal

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1/ See J.W. Friedman, 1999, Oligopoly and the Theory of Games, North Holland, Amsterdam,

2/ It may be shown that in most cases (2) or (3) provide a narrower range than that provided from the solution of the problem of the discriminating monopolist or monopsonist.

to the sum of the possible outcomes where each outcome is multiplied by the probability of its occurrence. If the buy : employs his jth strategy with a probability of one and the seller selects the probabilities $r_1, \ldots, r_m$, the seller's expected return is $\sum_{i=1}^{m} a_{ij} r_i$ (where a_{ij} is the seller's return if the seller employs his ith strategy and the buyer employs his jth strategy). The decision problem of each player is to select an optimal set of probabilities. The seller fears that the buyer will discover his strategy and that the buyer will select a strategy of his own that will maximize his expected outcome, i.e., minimize the expected return of the seller. The buyer has similar fears about the seller.

The probabilities vhich the two players employ are defined as optimal if

$$\sum_{i=1}^{m} a_{ij} r_i \geq V \qquad j=1, \ldots n$$

and

$$\sum_{j=1}^{n} a_{ij} s_j \leq V \qquad i=1, \ldots m$$

where V is the value of the trade between the seller and the buyer (i.e., the export earnings of Brazil from trade with the EEC). The first relation states that the seller's expected return is at least as great as V if the buyer employs any of his pure strategies with a probability of one. The second relation states the buyer's expected loss is at least as small as V if the seller employs any of his pure strategies with a probability of one. A fundamental theorem of game theory stater that a solution always exists and that V is unique. 1/ If both "players" select their strategies on a probabilistic basis, the seller's expected net return E_1 and the buyer's expected net outlay E_2 can be shown to be

$$E_1 = \sum_{j=1}^{n} \sum_{i=1}^{m} a_{ij} r_i s_j \geq V$$

$$E_2 = \sum_{j=1}^{n} \sum_{i=1}^{m} a_{ij} r_i s_j \leq V$$

which proves that

$$V = E_1 = E_2 = \sum_{j=1}^{n} \sum_{i=1}^{m} a_{ij} r_i s_j \qquad (4)$$

Regardless of the other "player's" choice, if the buyer or the seller employs his optimal probabilities, his expected outlay and return will not be less or greater than V, respectively. In the following chapter we will use relation (4) to estimate future expected returns. A number of simplifying assumptions regarding the intertemporal form of the two players' probability densities and their interrelationship will make the estimation of expected returns and the iron ore reference price possible.

III.2 Model Linkages

Figure 1 and Table 8 present the flowchart and the structure of the iron ore model, respectively. The iron ore price (Brazilian sinter fines 65% Fe CIF Rotterdam) is the outcome of bargaining between Brazilian and European representatives. Each participant desires different prices (P_1 and P_2). These

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1/ See, inter alia, J. Rosenmuller, 1981, The Theory of Games and Markets, North Holland, Amsterdam.

FIGURE 1: FLOWCHART FOR IRON ORE MODEL

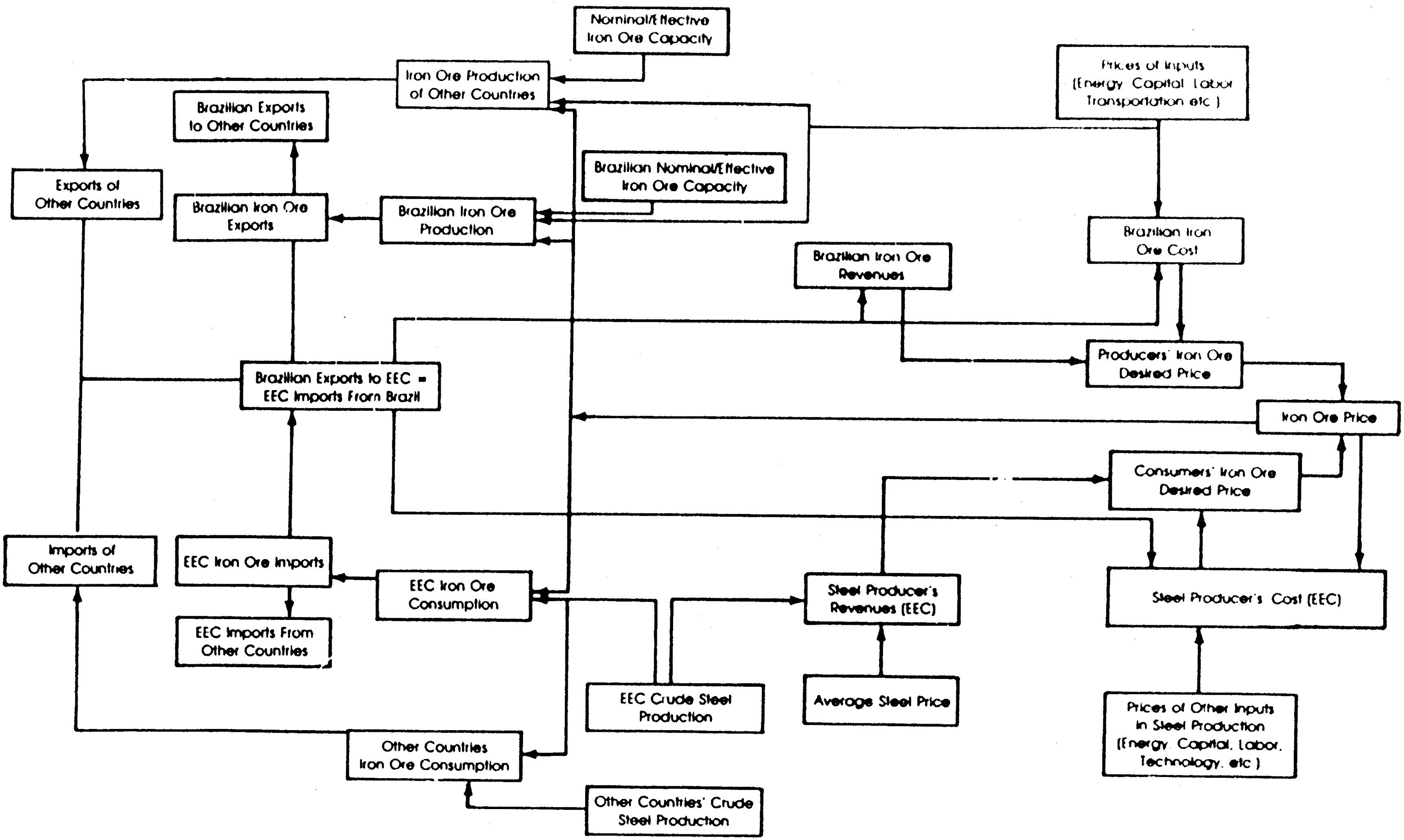

Table 8: THE STRUCTURE OF THE IRON ORE MODEL

Production

$$Q_i = f_{1i}\left(\frac{P_{xi}e_i}{P_{ki}}, \frac{P_{xi}e_i}{P_{ptri}}, \ldots \frac{P_{xi}e_i}{P_{gdpi}}; Q_{pi}\right) \qquad \forall i$$

Consumption

$$C_i = f_{2i}(Q_{si}, P_{mi}, P_{sci} \quad P_{si}, P_{ni}) \qquad \forall i$$

Exports, Imports

$$X_i = Q_i - C_i + \bar{M}_i \qquad \forall i$$

or

$$M_i = C_i - Q_i + \bar{X}_i \qquad \forall i$$

Prices

$$P_1 = EH^{Q_{B-1}} LOG\ (H) - (Q_{B-1}/A)$$

$$P_2 = \{M\ (P_s Q_{sE})_{-1}/C_{E-1}) - (C_{E-1}/L)$$

$$P_3 = EH^{QB-1}/QB-1$$

$$P_4 = [(P_s Q_{sE})_{-1} - OC_{-1}]/Q_{B-1}$$

if $P_1 > P_3$ and $P_2 < P_4$ then

continued...

...continued

$$\log P = a - 2 \, \mathrm{Log}\, (P_3 - P_4) + \beta \log S' / Q_B$$

if $P_3 \geq P_1$ and $P_4 \leq P_2$ then

$$\log P = \gamma - 2 \log (P_1 - P_2) + \delta \log S'' / Q_B$$

$$P_{xi} = f_5(P, Z_{5i})$$

$$P_{mi} = f_6(P, Z_{6i})$$

where

Q_{pi} = iron ore nominal or effective capacity for country i

Q_i = iron ore output for country i

Q_B = Brazilian iron ore output

Q_{si} = crude steel output for country i

Q_{sE} = crude steel output for EEC

P = iron ore reference price .

P_{xi} = export iron ore price for country i

P_{mi} = import iron ore price for country i

P_{ki} = rental price of capital in iron ore operations in country i

P_{ptri} = petroleum price in iron ore operations in country i

P_{gdpi} = GDP deflator of country i

P_{ni} = prices of other than iron ore and scrap pricer in the steel production process

C_i = iron ore apparent consumption for country i

continued...

...continued

C_E = iron ore apparent consumption for EEC

P_{sCi} = price of scrap in country i

X_i = exports of iron ore in country i

M_i = imports of iron ore in country i

X_B = exports of Brazilian iron ore

M_E = imports of iron ore of EEC countries

P_s = average wholesale steel prices in EEC

P_1 = "desired" iron ore price of Brazilian iron ore producers (solution of discriminating monopolist problem)

P_2 = "desired" iron or price of EEC steel mills (solution of discriminating monopsonist problem)

P_3 = iron ore price that will not put (major) iron ore producers out of business

P_4 = iron ore price that will not put Continental Europe's steel mills out of business

OC = costs of steel production other than iron ore in Continental Europe

$\alpha, \beta, \gamma, \delta, S', S''$ = parameters related to price formation

E, H, A = parameters related to marginal revenue and marginal cost of Brazilian iron ore producer

N, L = parameters related tc marginal product and marginal cost of EEC steel mills

Z_{6i}, Z_{7i} = exogenous variables

e_i = exchange rate of the currency of country i with respect to the US$.

two desired prices affect the outcome of the negotiations. The agreed sinter fines price (P) becomes the benchmark for adjusting other iron ore prices. Export and import iron ore prices (P_x, P_m) also reflect changes in the reference price. Export prices in local currency serve as proxies for producer prices.

The production of iron ore (Q), constrained by effective capacity, depends on the vhole group of unit factor costs and on the price of output. The "price-taker" characteristic of the exporter (as far as quantities are concerned), is reflected in the adjustment of exportr to production. The function of apparent consumption of iron ore (C), reflecting the profit maximization process of the steel producer, is a function of steel output, iron ore price and the price of substitutes such as scrap. Imports are determined by consumption (after adjusting for domestic production and exports, if any). The exports of Brazil to the EEC (by definition equal to the imports of EEC from Brazil) are influenced by not only the trade patterns of Brazil and the EEC but also by the expected demand and supply of iron ore in the particular year. Brazilian exports to the EEC affect Brazilian iron ore revenues and costs and EEC steel production costs. The equality between iron ore producers* marginal cost and marginal revenue determiner the "desired" Brazilian iron ore price (P_1) and the equality between steel producer's marginal revenue of additional unite of iron ore and their marginal cost determines Continental Europe's "desired" iron ore price (P_2). The negotiated iron ore price (P) is determined within the boundary prices, P_1 and P_2. The price (P) satisfies also the constraint that none of the major iron ore producers nor Continental Europe steel producers will go out of business, i.e., $P_4 \leq P \leq P_3$. With the exception of Brazil and the seven EEC countries, all other countries are treated in the same way. Each country has its own potential output, actual output, exports, imports, apparent consumption and price functions. The model recognizes 30 countries and regions.

IV. EQUATION SPECIFICATION

IV.1 Iron Ore Production

Actual output for each country is derived through profit maximization of the iron ore producer subject to his production function. From the theory of the firm we have:

real factor cost (ith factor) = marginal productivity (ith factor)

output = f (ℓ factor inputs)

or
$$\frac{W_i}{P} = m_i(h_i, \ldots, h) \quad i=1, \ldots, \ell \qquad (5)$$
$$Q = f(h_1, \ldots, h_\ell)$$

where

W_i = factor cost i

P = producer price of iron ore

h_i = inputi

Q = iron ore output

From (1) we have 1/

$$h_i = x_i\left(\frac{W_1}{P}, \ldots, \frac{W_\ell}{P}\right)$$

and after substitution of each of the x_i functions into the production function we get

$$Q = f(x_1, \ldots, x_\ell) = S\left(\frac{W_1}{P}, \ldots, \frac{W_\ell}{P}\right) \quad \text{or}$$

1/ The marginal productivity functions are assumed inverrable.

$$Q = f\left(\frac{P_x}{P_k}, \frac{P_x}{P_{ptr}}, \ldots, \frac{P_x}{P_{gdp}}; Q_p\right)$$

where

P_k = rental cost of capital

P_{ptr} = petroleum price

P_{gdp} = GDP deflator

P_x = producer price of iron ore in domestic currency

Q_p = potential iron ore output

This is the supply function of iron ore. It depends on the vhole group of unit factor costs and the price of output, although it is customarily drawn as a function of output price alone.

As iron ore producer prices are not available, they are replaced here by the relevant export unit values in domestic currency, Factor unit costs are also not always available. Proxies have been thus used. For example, the rental price of capital (P_k) has been replaced by a proxy estimated by the following formula

$$P_k = PIB \frac{\lambda + \varpi}{1 - TX}$$

where

PIB = investment deflator (national accounts)

λ = depreciation rate

ϖ = coot of capital

TX = direct corporate tax rate (where relevant), In the absence of an organized market for capital services the above formula is an attempt to approximate the implicit cost per time period of owning and operating capital equipment. In order to offset the lack of domestic savings, Governments obtain credit from external sources, or provide guarantees for private sector borrowing abroad. In addition, they encourage foreign airect investment. There funds are channeled to the investment project. Often the external component is a major part of the finance of these projects. Under these circumstances, thr cost of foreign capital (m) could be a very relevant measure of the overall coot of capital in developing countries. The US treasury bond rate for three months is ured here as the interest rate on external financing. 1/

Similarly, the veighted average OPEC price for crude oil (P_{ptr}) is used as a proxy for energy costs in the production process. Energy costs are particularly important when the country in question producer mostly pellets.

Other proxies that are used to reflect factor unit costs of production are the gross domestic product deflator or the consumer price index of the country in question. In order to reflect technological changes or changer in the quality of the iron ore mined as well as the relative depletion of the mine, a variable approximating a trend, such as the effective capacity; has been introduced in the production equation. As supply may not respond immediately to changes in current factor unit costr and current iron ore prices, a Koyck-Nerlove transformation and other lag distributions have been considered. The supply elasticities corresponding to the different factor unit costs are presented in Table 9.

1/ A possible alternative cost measure, the implicit rate from the balance-of-payments interest payments on medium- and long-term debt, is not ured, as it is difficult to separate debt rescheduling and unreported capital transactions.

Table 9: ELASTICITIES OF IRON ORE SUPPLY

COUNTRY	INDEPENDENT VARIABLES /A								
	$P/P_{ptr}(-1)$	$P.e/P_{gdp}$	P/P_{gdp}	P	P/P_k	P_k	Q_p/B	Q(-1)	$Q/Q_p(-1)$
CANADA	0.23	0.49					2.19		
UNITED STATES	0.04								0.62
GERMANY, FED. REP.			0.14				0.21	0.78	
FRANCE	0.05					-0.03	0.43	0.49	
BELGIUM /C	0.13		0.13					0.92	
SWEDEN		0.18					1.05	0.42	
UNITED KINGDOM /C	0.10						0.56	0.47	
SPAIN		0.27					1.94		
AUSTRALIA		0.55					1.24	0.41	
SOUTH AFRICAN REP.		0.45					0.95	0.43	
ALGERIA /C					0.12		1.38		
LIBERIA							0.70	0.12	
EGYPT /C			0.28				0.47	0.72	
MAURITANIA		0.18					0.99		
INDIA					0.05		1.10		
YUGOSLAVIA /C			0.05				0.70	0.63	
TURKEY /C							0.55	0.49	
BRAZIL		0.11					0.59	0.54	
CHILE				0.30		-0.23	0.41	0.47	
MEXICO		0.27					0.84	0.36	
PERU	0.04						0.74	0.33	
VENEZUELA							0.60	0.25	
USSR							1.06		
CZECHOSLOVAKIA /C							0.18	0.73	
CHINA							0.93	0.33	
ITALY /C							1.05	0.21	
KOREA /C			0.19					0.52	

/A P_k : RENTAL COST OF CAPITAL IN DOMESTIC CURRENCY.
P : IRON ORE EXPORT UNIT VALUE.
P_{ptr} : OIL PRICE IN DOMESTIC CURRENCY.
P_{gdp} : GROSS DOMESTIC PRODUCT DEFLATOR OR CONSUMER PRICE INDEX.
Q : ACTUAL OUTPUT ff IRON ORE.
e : EXCHANGE RATE.

/B THE ELASTICITY ff Q_p OR OF Q_p + Q(-1) COULD BE GREATER THAN ONE; THE METAL CONTENT OF RECOVERABLE ORE MAY IMPROVE WITH TIME. THE DATA REFLECT THE HISTORICAL PERIOD: 1960-1984.

/C NOT IMPORTANT PRODUCER, MTA MAY LEAD TO MISSPECIFICATION.

SOURCE: ANNEX II.

The elasticity of potential output varies between 0.5 and 2.2. Most often it is close to 1. Elasticities above 1 indicate capacity increases with higher metal content than in the past. Technological developments and increased production of pellets night a! so cause the elasticity of potential output to be higher than one in the historical period. Actual output has been constrained to take values equal Lo potential output whenever $Q \geq Q_p$. Potential output is exogenously determined. 1/ Price elasticities vary substantially among countries. The ratio of iron ore export unit value to a general domestic indicator of the cost of inputs in the iron ore production process (such as the CDP deflator or the consumer price index) in US dollars or in domestic currency has been used most of the time. The elasticity of (P/P_{gdp}) varies between 0.05 and 0.28 and the elasticity of $(P.e/P_{gdp})$ varies between 0.11 and 0.55. With the exception of Canada, the elasticity of (P/P_{ptr}) ranges between 0.04 and 0.13. The elasticity for Canada is 0.23. The rental cost of capital (P_k) was significant statistically in four countries. The elasticity of (P/P_k) or (P_k) was less than 0.23% in all four cases. Overall, a 1% increase in the iron ore export unit value increases iron ore supplies between 0.04% and 0.82%. In 15 out of 20 cases, however, iron ore output increases by less than 0.32. In seven countries, mostly small or

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1/ Potential or effective capacity has been calculated based on peak production volumes on a country-by-country basis for the 1960-84 period. The ratio of effective to nominal capacity is calculated based on nominal and effective capacity figurer for the years 1980 to 1984. The mean of this ratio is used to estimate future effective capacity given engineering estimates on future nominal capacity.

centrally planned economies, producer price changes were not found to have any impact on iron ore supplies. 1/

IV.2 Apparent Consumption

Iron ore is an input in the steel production process. The demand for iron ore is determined through either the profit maximization process or the cost minimization process of the steel producer. The two methods produce similar demand-for-input functions.

Profit Maximization

$$\max \Pi = R(q_1, \ldots, q_n) - \Sigma V_k W_k$$

as long as the set of inputs V and outputs Q is a producable combination

$$\Rightarrow \quad V_i = g^{V_i}(W;R) \qquad (6)$$

Cost minimization

$$\min \Sigma V_k W_k$$

subject to

$$q_s^o = Q(V)$$

$$\Rightarrow \quad V_j = g^{V_j}(W,q) \qquad (7)$$

where:

W_k	=	price of input k (iron ore is one of there inputs)
V_k, V_i, V_j	=	quantity of input k, i, j, respectively
$q_1, \ldots, q_n, q_s$	=	outputs 1, ..., n, s, respectively (there are the steel products)
q	=	set of q_1 to q_n
R	=	revenue of steel producer
Π	=	profit of steel producer

1/ Annex II lists all equations of this model.

Profit maximization and cost minimization result in a demand-for-iron ore function that depends on the price of iron ore and the price of other inputs. Under the profit maximization method, the demand for iron ore is also a function of revenues, while under the cost minimization method the demand for iron ore is a function of the output produced. The two methodr are equivalent, however, and result in the same functional form if under profit maximization the prices of steel products are assumed to be exogenourly determined or given. The common functional form for these two methods could be then written as follows:

$$C = f(Q_s, P_m \cdot e, P_{sc} \cdot e; P_s, P_N)$$

where

C	=	apparent consumption of iron ore
Q_s	=	crude steel production
	=	iron ore import unit deflator
P_{sc}	=	scrapprice
P_s	=	steel product prices
P_N	=	prices of other inputs in the steel production process
e	=	exchange rate

Changes in iron ore prices are assumed here to have no impact on the use of inputs, other than rcrap. Functional form (7) has been thus chosen for estimating the apparent consumption equations. Lack of relatively long historical data on steel product prices (on a country-by-country basis) is the main reason for choosing this more restricted functional form. Table 10 shows

Table 10: ELASTICITIES OF IRON ORE APPARENT CONSUMPTION

COUNTRY	INDEPENDENT VARIABLES /A			
	Q_s	$P_m \cdot e$	$P_{sc} \cdot e$	C(-1)
CANADA	1.01	-0.07	0.12	
UNITED STATES	0.77	-0.16	0.07	
GERMANY, FEDERAL REP. OF	0.91	-0.05	0.13	0.16
FRANCE	0.37	-0.19	0.14	0.46
BELGIUM	0.63	-0.17		0.22
NETHERLANDS	0.59	-0.04	0.25	0.26
UNITED KINGDOM	1.08	-0.10	0.07	-0.10
SPAIN	0.48	-0.13		0.53
ITALY	1.03	-0.15	0.19	
JAPAN	0.81	-0.05	0.03	0.28
AUSTRALIA	1.36			
SOUTH AFRICA	1.07	-0.04 /A /C		
USSR	0.30			0.63
CZECHOSLOVAKIA	0.54			
CHINA	0.82	-0.12	0.07	
INDIA	1.33	-0.31 /C		0.36
KOREA, REPUBLIC OF	1.10	-0.64	0.18	0.29

/A Q_s = CRUDE STEEL OUTPUT
P_m = IRON ORE IMPORT UNIT VALUE
= SCRAP PRICE
e = EXCHANGE RATE
C = IRON ORE APPARENT CONSUMPTION
/B WITH ONE YEAR LAG.
/C EXPORT RATHER THAN IMPORT UNIT VALUE HAS BEEN USED HERE.

SOURCE: ANNEX II.

the elasticities of demand of the estimated equations. 1/ The elasticity with respect to crude steel output ranges between 0.3 and 1.36. Host traditional steel producing countries, however, have an elasticity close to or below 1. Overall, a 1% increase in steel production is not likely to result in substantially higher increases in iron ore demand <u>ceteris paribus</u>. The iron ore price elasticity ranges between 0.04 and 0.64 in absolute terms. With the exception of the Republic of Korea .. India, all price elasticities are less than 0.02 in absolute terms. Scra[illegible] elasticities range between 0.03 and 0.25. Scrap competes with iro.. ore in the s eel production procern. This explains the difference in signs. The iron ore price elasticity for the Republic of Korea is surprisingly high. The relatively high dependence of the Republic of Korea's steel production process on scrap rather than on iron ore (until very recently) may explain this high elasticity.

IV.3 Exports and Imports

Most iron ore producers are important exporters and most iron ore consumers are often important importers. With a few exceptions such as Brazil, India and Sweden, 'important iron ore exporters are not important iron ore consumers. For that reason the following set of identities have been used on a country by country basis accordingly:

for iron ore exporters

$$X = Q - C + \bar{M}$$

1/ See Annex II for a list of all apparent consumption equations. It is noteworthy that apparent consumption figures include changer in stock. Indurtry experts estimate that for most countries stocks relatively to iron ore consumption do not change on an annual basis. Stocks change on A rearonal basin only.

and for iron ore importers

$M = C - Q + \bar{X}$

where

Q = iron ore production

C = iron ore apparent consumption

M = iron ore imports (the bar indicates that the variable is exogenous)

X = iron ore exports (the bar indicates that the variable is exogenous)

IV.4 Prices

As we saw in Section 1 of Chapter III, the expected earnings of the iron ore producer may be estimated through (4). This equation is generalized through time as follows:

$$r_t A_t s_t = V_t \tag{8}$$

where

r_t = row of r_{it} from probability density function $\underset{\sim}{r}$ $\forall t$

s_t = column of s_{it} from probability density function $\underline{s}$ $\forall t$

A_t = matrix of a_{ijt} for $\forall t$

Equation (8) may be estimated if the following are known:

(a) The probability density functions $\underset{\sim}{r}$ and $\underline{s}$; and

(b) The outcomes of all the strategies, A.

Unfortunately as negotiations are kept secret neither (a) nor (b) are known. The following assumptions are made:

First, r and s are assumed to be uniform density functions 1/ of the form:

$$r(x) = \begin{cases} \frac{1}{x_1 - x_2} & \text{for } x_2 < x < x_1 \\ 0 & \text{elsewhere} \end{cases}$$

and

$$s(x) = \begin{cases} \frac{1}{x_1 - x_2} & \text{for } x_2 < x < x_1 \\ 0 & \text{elsewhere} \end{cases}$$

where x_1, x_2 are constants vith $x_2 < x_1$

Here x_2 could be the unit value of Brazil-Continental Europe trade if priced at "desired" Continental Europe iron ore prices or at such prices that Continental Europe will not get out of burinerr. Similarly, x_1 could be the unit value of Brazil-Continental Europe trade if priced at "desired" Brazilian iron ore prices or at such prices that Brazil and the ocher major iron ore producers do not get out of business.

Second, A_t is assumed to depend on past A's. Equation (8) may be revritten as follows:

1/ Density functions of other forms could be used. The mathematical simplicity of the uniform function makes it attractive here.

$$V_t = \frac{A_t}{(x_{1t}-x_{2t})^2} \quad (9)$$

if

$V_t = P_t \cdot Q_t$

$x_{1t} = P_{1t}$ and

$x_{2t} = P_{2t}$

then (9) can be rewritten as

$$P_tQ_t = A_t | (P_{1t} - P_{2t})^2 \quad (10)$$

and in logarithmic terms

$$\log P_t Q_t = \log A - 2 \log (P_{1t} - P_{2t}) \text{ or}$$

$$\log P_t = \log A - 2 \log (P_1t - P_2t) - \log Q_t \quad (11)$$

The Brazilian "desired" sinter fines price (P_{1t}) is derived from setting the marginal cost equal to the marginal revenue of iron ore producers. 1/ If the iron ore producer faces a demand function with

$$\frac{\partial Q}{\partial P} = A$$

and the cost function of the iron ore producer is represented by

$$CT_e = EH^{Q_e} \quad (12)$$

1/ The words "desired price" are used here to quantify the outcome of a strategy. "Desired prices" do not refer to actual prices. They can take negative values.

where

CT_e = total expected cost for producing 51.5 Fe units and transporting them to the final consumer

Q_e = iron ore output

then from (1) and (2), profit maximization and expectations for output (of the form $Q_e = Q_{-1}$) ve get:

$$P_1 = EH^{Q_{-1}} \log H - Q_{-1}/A \qquad (13)$$

Equation (13) provides an estimate of the "desired" iron ore price from the Brazilian perspective. The cost function has been estimated based on cross-sectional data collected from the US Bureau of Hines. In their study, Brazil and Australia with some African countries other than Liberia, have been found less costly than Venezuela, India, Liberia and the United States. The cross-sectional data are pooled together in the following equation:

$$CT = 0.1434 * 1.0506^{Q}$$

where

CT = cumulative cost of iron ore production

Q = iron ore output

The weighted average of the marginal propensities of demand (see section on apparent consumption) of EEC countries (Luxembourg has been assumed to have the same elasticity as Belgium) has been calculated to be -0.0269. 1/ The average 1960-84 share of apparent consumption to total EEC Apparent consumption has been used as the weight in the calculation.

The "desired" EEC-7 iron ore price (P_2) is derived by setting the marginal revenue with respect to iron ore equal to the marginal cost of the EEC-7 steel mill producers. If the Brazilian iron ore supply's slope is

$$\frac{\partial Q}{\partial P} = L$$

and if $TC = PC + \ldots$

where

TC = total cost of crude steel production in EEC

C = iron ore consumption

P = EEC iron ore price

Furthermore if

$$R_{se} = P_{se} Q_{se}$$

where

R_{se} = expected revenues of EEC steel producers

P_{se} = expected average price of steel products

Q_{se} = expected EEC crude steel output

1/ Long-term propensities are used here.

and if the production functions if EEC producers are represented by Cobb-Douglas production functions with variable returns to scale, then the profit maximization of steel producers with respect to iron ore is equal to the marginal cost. By solving this equality for output and price we get 1/

$$P_2 = \left(N(P_sQ_s)_{-1}/C_{-1}\right) - \left(C_{-1}/L\right) \qquad (14)$$

The weighted average of the marginal product of EEC steel producerr with respect to iron ore (N) is estimated to be 0.20. 2/ The long-run price propensity of Brazilian iron ore supply is calculated at 0.091 (see section on iron ore output estimation),

P_1 and P_2 could be also replaced by P_4 and P_3, respectively, in equations (9) to (11). P_3 is the minimum price that will 'keep European steel mill operations profitable. P_4 is the minimum price that will keep Brazilian and other major iron ore producers in business. When Europe's profits in steel production become zero, then

$$P_{se}Q_{se} = P_eQ_e + OC_e$$

$$\text{or} \quad P_e = \frac{P_{se}Q_{se} - OC_e}{Q_e}$$

1/ It is also assumed here that steel producers adopt expectations of the form $R_e = R_{-1}$ or $(P_s \cdot Q_s)_e = (P_s \cdot Q_s)_{-1}$.

2/ The marginal product of major EEC steel producers with respect to iron ore and other inputs has been estimated by T. Priovolos, 1987, Investment Policies for Steel Producing Countries: An Empirical Analysis of the Use of Iron Ore by Major Steel Producing Countries, The World Bank Division Working Paper 1987-2, Washington, DC.

where

P_s = actual steel products price

Q_s = actual steel production

P_{se} = expected EEC steel products-price

Q_{se} = expected steel output, EEC

OC_e = expected other than iron ore costs in EEC steel production

P_e = expected iron ore price

Q_e = expected iron ore used in EEC steel production

Q = actual iron ore volume used in EEC steel production

and then 1/

$$P_3 = \frac{(P_s Q_s)_{-1} - OC_{-1}}{Q_{-1}} \tag{15}$$

When Brazil's profits become zero, then

$$P_e Q_e = EH^{Q_e}$$

or

$$P_e = \frac{EH^{Q_e}}{Q_e}$$

where

E, H = parameters related to cost function (13)

Q_e = expected iron ore output

1/ Expectations of the form $P_{se}Q_{se} = (P_sQ_{s-1})$, $Q_e = Q_{-1}$ and $OC_e = OC_{-1}$ are assumed here.

and then 1/

$$P_4 = \frac{\frac{EH}{Q_{-1}}}{Q_{-1}} \quad (16)$$

Equation (11) implies that the value of Brazil/Europe trade is a function of the range P_1-P_2 and of the sum of all possible outcomes of the "game", A. If the range P_1-P_2 is a function of P_1 and P_2 and A is calculated auto-regressively then equation (11) may be estimated as follows:

$$\log IOPRCDMC2 = \underset{(-1.61701)}{-0.487243} + \underset{(0.613730)}{0.478422} * \log YY - \underset{(-4.8815)}{5.45467} * \log XC$$

R-Squared:0.927 (Uncorrected!	R-Squared:0.920 ('Corrected)	SEE:0.76117E-01	DW:1.223
F(2,21): 133.179	RSS: 0.12167		

where YY is the transformation of the right hand side variables of equation (11), MC is the metal content adjustment factor of sinter fines, 2/ IOPRCDMC2 is the Brazilian FOB sinter fine price expressed in metal content.

The properties of this equation are the same as those of equation (11). The value of trade (P*Q) 3/ increases with a decline in the range P_1-P_2.

1/ Expectations of the form $Q_e = Q_{-1}$ are assumed here.

2/ The coefficient of MC is not 1 due to the fact that MC is total world iron ore production metal content including pellets, lump, etc.

3 Long and continuous statistical data series on Brazil, Continental Europe traded volume are not existent. For that reason, the Brazilian iron ore production has been used here as a proxy for Q.

Furthermore, the range P_1-P_2 declines with P_1 decreasing and P_2 increasing. 1/ This relation is replicated with our estimation above. The value of trade, (P*Q), increases when P_1 decreases and when P_2 increases. Iron ore demand considerations prevail in the negotiations. Brazilian negotiations will increase their revenues when their "desired" price moves closer tc that of Europe's. 2/

1/ P_2 is negative here. The same would hold if P_2 was positive.

2/ The same analysis holds when P_4 and P_3 are used instead of P_1 and P_2. When the price (P_4) that puts out of business iron ore producers increases and the price (P_3) that puts out of business steel producers increases the range P_4-P_3 increases and iron ore prices tend to decrease, i.e., iron ore prices tend to decrease as iron ore production becomes more profitable and steel production becomes less profitable.

V. MODEL VALIDATION AND MULTIPLIER ANALYSIS

V.1 Model Validation

This section examines the overall performance of the world iron ore model. The results of dynamic historical simulation over the 1974-84 period are presented for the most important variables of the model in Table 11.

The root mean square percentage errors (RMSPE) of apparent consumption vary between 0.86% and 18.96%. The worst results are those for the Republic of Korea. There results are partly a reflection of the data and partly of the equation specification. The Republic of Korea has developed its steel industry, mostly electric furnaces, in the last ten years. Thus, for a very long time, 1965-75, consumption of iron ore was not significant, In the 1975-80 period, consumption of iron ore increased fivefold with the development of furnaces consuming iron ore. In the first half of the 1980s, consumption of iron ore and steel capacity stabilized in the Republic of Korea. South Africa and India are the other two countries with over 10% RMSPE in apparent consumption. Both countries had unusually low levels of iron ore consumption in 1970. In addition, South Africa has an unusually high level of consumption in 1977. Thus the estimated coefficients of the respective equations may not be the true ones.

The RMSPEs of production have been higher than those of apparent consumption. They range between 2.04% and 19.66%. Data problems may be the cause of these high RMSPEs. Our iron ore production data do not distinguish between pellets and sinter fines. In addition, closely "captured" mines in one

Table 11: ERROR STATISTICS FOR MAJOR VARIABLES: HISTORICAL SIMULATION (1974-84)

	MEAN ERROR	ROOT MEAN ERROR	MEAN % ERROR	ROOT MEAN % ERROR
APPARENT CONSUMPTION				
CHINA	1.76	2.03	4.90	5.68
GERMANY, FED. REP. OF	0.52	0.62	1.89	2.24
EEC-7	0.86	1.00	1.43	1.68
SPAIN	0.27	0.33	4.11	5.13
FRANCE	0.45	0.54	2.98	3.61
UNITED KINGDOM	0.35	0.39	4.11	4.90
INDIA	1.02	1.31	9.10	11.83
ITALY	0.55	0.70	5.43	6.90
JAPAN	2.47	3.09	3.33	4.26
KOREA, REP. OF	0.40	0.49	14.45	18.96
NETHERLANDS	0.32	0.37	8.24	9.51
SOUTH AFRICA	0.64	0.37	8.43	11.84
UNITED STATES	4.12	4.84	7.43	8.84
USSR	0.73	0.99	0.64	0.86
WORLD	7.74	9.13	1.63	1.91
PRODUCTION				
AUSTRALIA	3.76	4.45	6.91	8.34
BRAZIL	3.37	4.17	5.86	7.49
CANADA	2.99	3.92	11.23	14.93
CHILE	0.74	0.93	13.32	16.06
CHINA	1.56	1.96	4.76	6.49
SPAIN	0.19	0.24	4.43	5.46
FRANCE	0.55	0.70	5.46	6.72
INDIA	1.05	1.34	4.31	5.60
LIBERIA	0.78	0.86	6.17	6.96
MEXICO	0.27	0.33	6.83	8.96
MAURITANIA	0.58	0.75	11.24	15.92
PERU	0.34	0.46	8.89	12.83
SOUTH AFRICA	1.94	2.43	14.97	19.66
SWEDEN	2.03	2.30	15.27	18.99
UNITED STATES	4.25	6.16	10.98	16.61
USSR	2.63	2.71	2.00	2.04
WORLD	13.75	17.08	2.89	3.72
OTHER VARIABLES				
WORLD EXPORTS	12.01	14.29	5.46	6.71
WORLD IMPORTS	7.53	9.37	3.45	4.30
BRAZILIAN IRON ORE DEFLATOR	1.13	1.33	5.02	6.03

SOURCE: THE WORLD BANK, INTERNATIONAL ECONOMICS DEPARTMENT.

country (such as in Canada) by steel producers in another (such as the United States) complicate the equation specification of a particular country's production process. Data problems account for the high RMSPEs of Chile, South Africa, Mauritania and Mexico. The sinter fines/pellet problem is inherent in all the countries but it becomes particularly important in the cases of Sweden, Canada, the United States, Chile and Peru. Lack of reasonably good output data by type of iron ore on a country-by-country basis limit the possibilities for improvement in the specification of these equations.

The Brazilian/Continental Europe reference iron ore price deflator (P) has a 6.022 RYSPE. The main source of error is the "desired" Brazilian price which depends inter alia on the production of several countries--among them the United States and Brazil. The equation that estimates the US output is statistically weak. As previously stated, the data is also the main problem here. First, the lack of distinction between pellets and sinter fines and second the problem with the "captured" mines do not allow substantially better equation specification than that one used. When US production is exogenized the Brazilian/Continental Europe reference iron ore price has a lower RHSPE, close to 3%. However, the reasonable RMSPE values for the iron ore reference price points to the fact that this model can be used equally well for price forecasting and policy simulation. Estimation of dynamic multipliers will be used in the next section to analyze several policy scenarios.

V.2 Multiplier Analysis

This section analyzes the impact of sustained changes in selected exogenous variables in the other variables of the iron ore model. The control and the disturbed solutions are compared and dynamic multipliers are estimated. For any time point, the spread between the two paths, i.e., the control and the disturbed solutions, shows the dynamic multiplier at that point. In the following tables (12) to (16), the mean (over a ten-year period) of the spread in percentage terms is presented. Dynamic multipliers are important because they show the responsiveness of the node1 to exogenous shocks nnd because they quantify the shocks' impact on the rest of the commodity economy.

V.3 sustained Increase in Brazilian Iron Ore Capacity

This scenario simulates the impact of a 1% increase in Brazilian capacity on the rest of the iron ore economy. Recently Brazil otarted operations in the Carajas project. At full capacity, by 1990, the Carajas project could add some 35 million tons to Brazilian production. The World Bank estimates that total Brazilian capacity in metal content will increase by 25 million tons (or 31%) between 1985 and 1990. 1/ In this scenario, the capacity increase is assumed to be sustained over the entire ten-year period. The results of the simulation are presented in Table 12.

As expected, Brazilian production increases (by 0.9%) in response to a 1% increase in capacity. Proportionately, Brazilian exports increase more than production. With higher rates of production and thus of depletion of its natural resources, Brazil desires a higher price in the contractual negotiation;. The Continental European countries feel that the additional Brazilian production exacerbates the existing over-capacity in the iron ore markets; they are willing to accept additional Brazilian iron ore for lower prices. The stronger negotiating position of Continental Europe's steel mills

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1/ See Report No. 814/86, The World Bank, International Economics Department, October 1986, Price Prospects for Major Primary Commodities.

Table 12: DYNAMIC MULTIPLIER ANALYSIS: A SUSTAINED INCREASE IN BRAZILIAN IRON ORE CAPACITY (% P.A.)

COUNTRY	IRON ORE APPARENT CONSUMPTION	IRON ORE PRODUCTION
AUSTRALIA		-0.37
BELGIUM	0.49	
BRAZIL		0.90
CANADA	0.15	-1.11
CHILE		-[illegible].49
CHINA	0.16	
FRANCE	0.61	
GERMANY, FED. REP. OF	0.08	
INDIA	0.58	-0.05
ITALY	0.23	
JAPAN	0.06	
KOREA, REP. OF	1.27	
MAURITANIA		-0.12
MEXICO		-0.24
NETHERLANDS	0.05	
PERU		-0.20
SOUTH AFRICA	0.04	-0.45
SPAIN	0.32	
SWEDEN		-0.28
UNITED KINGDOM	0.22	
UNITED STATES	0.88	-0.37
	IRON ORE PRICE	
REFERENCE PRICE BRAZIL/CONT. EUROPE	-0.87	
DESIRED BRAZILIAN PRICE	0.96	
DESIRED CONT. EUROPE PRICE	-0.38	

SOURCE: THE WORLD BANK, INTERNATIONAL ECONOMICS DEPARTMENT.

is reflected in the final outcome. Ircn ore reference prices decline by an average 0.87% p.a. Lover iron ore prices cause production to decline and consumption to increase. The countries that are expected to reduce proportionally more their output in response to the Brazilian capacity increase are Canada (-1.11%), Chile (-0.43%), and South Africa (–0.45%). The countries that are expected to be least affected are India (-0.05%) and Mauritania (-0.12%). Among the countries that are expected to increase their consumption the most are the Republic of Korea (1.27%), the United States (0.88%) and Prance (0.61%). South Africa, Japan snd the Federal Republic of Germanv are not expected to significantly change their consumption of iron ore.

V.4 Sustained Increase in EEC-7 Crude Steel Production

This scenario simulates the hypothetical impact of a 1% sustained increase in EEC-7 crude steel production on iron ore markets over a 10–year period. The seven EEC countries whose crude steel production is assumed to increase are: the Federal Republic of Germany, Prance, Italy, the United Kingdom, the Netherlands, Belgium and Luxembourg. All seven countries increase their consumption and imports of iron ore. The Federal Republic of Germany, the United Kingdom, Italy and the Netherlands increase their consumption by 0.96%, 0.79%, 0.76% and 0.69% p.a., respectively (see Table 13). Belgium and 'Luxembourg increase their consumption by 0.4%, while Prance increases its iron ore consumption by a mere 0.012. These different percentage changes show the different restructuring plans o! the steel industry of each country. Prance and Belgium are expected to go more rhe electric furnace/scrap–use route rather than the blast furnace/iron ore–use route. Overall, a 1% increase in EEC crude steel production is expected to increase iron ore consumption by

Table 13: DYNAMIC MULTIPLIER ANALYSIS: A SUSTAINED INCREASE IN EEC-7 CRUDE STEEL PRODUCTION (IN % P.A.)

COUNTRY	IRON ORE APPARENT CONSUMPTION	IRON ORE PRODUCTION
AUSTRALIA		0.48
BELGIUM	0.40	
BRAZIL		0.20
CANADA	-0.18	1.12
CHILE		0.61
CHINA	-0.20	
FRANCE	0.01	
GERMANY, FED. REP. OF	0.96	
INDIA	-0.74	
ITALY	0.76	
JAPAN	-0.77	
KOREA, REP. OF	-1.56	
MAURITANIA		0.16
MEXICO		0.33
NETHERLANDS	0.69	
PERU		0.16
SOUTH AFRICA	-0.05	0.57
SPAIN	-0.40	
SWEDEN		0.35
UNITED KINGDOM	0.79	
UNITED STATES	-1.07	0.29
	IRON ORE PRICE	
REFERENCE PRICE BRAZIL/CONT. EUROPE	1.23	

SOURCE: THE WORLD BANK, INTERNATIONAL ECONOMICS DEPARTMENT.

less than 1%. Increased iron ore demand causes iron ore prices to rise. The iron ore reference price grows by 1.23% p.a. Higher iron ore prices cause production of iron ore to increase and consumption of iron ore to decline. Among the producers, Canada, Chile, South Africa and Australia increase their output the most (i.e., between 0.48% and 1.12%), while Peru, Mauritania and Brazil increase their output relatively the least (i.e., between 0.16% and 0.20%). Among the consumers, the Republic of Korea, the United States and Japan reduce their iron ore consumption the most (i.e., between -1.56% and -0.77%) and Canada and China the least (-0.18% and -0.20%).

V.5 Sustained Increase in Scrap Prices

The scenario traces the responsiveness of behavior in the iron ore model to changes in scrap prices. The impact of a 1% sustained increase in scrap prices on the iron ore markets is presented in Table 14. Higher scrap prices make iron ore prices more competitive in the steel production process in the short run. As a result, iron ore consumption increases in almost all countries. The increases in consumption are small, however--they range between 0.01% in Japan and 0.33% in the Netherlands 1/. In view of the increased demand for iron ore (see previous section), the Brazilian negotiating position prevails and the iron ore reference price increases by 0.35% p.a. Higher iron ore prices cause iron ore production to increase, Production increases vary between 0.06% in Brazil and Peru and 0.36% in Canada. Higher iron ore prices also cause the competitive advantage of iron ore prices vis-a-vis that of scrap prices to decline. This is the reason why the multiplier of consumption is relatively small over a ten-year period.

1/ In three countries (Belgium, the United States and the Republic of Korea) consumption increases at first and declines after some years.

Table 14: DYNAMIC MULTIPLIER ANALYSIS: A SUSTAINED INCREASE IN SCRAP PRICES
(IN % P.A.)

COUNTRY	IRON ORE APPARENT CONSUMPTION	IRON ORE PRODUCTION
AUSTRALIA		0.13
BELGIUM	-0.20	
BRAZIL		0.06
CANADA	0.11	0.36
CHILE		0.18
CHINA	0.02	
PRANCE	0.16	
GERMANY, FED. REP. OF	0.16	
INDIA		0.01
ITALY	0.17	
JAPAN	0.01	
KOREA, REP. OF	0.06	
MAURITANIA		0.05
MEXICO		0.09
NETHERLANDS	0.33	
PERU		0.06
SOUTH AFRICA		0.16
SUEDEN		0.11
UNITED KINGDOM	0.06	
UNITED STATES	-0.07	0.09
	PRICES	
SCRAP PRICE	1.00	
IRON ORE REFERENCE PRICE BRAZIL/CONT. EUROPE	0.35	

SOURCE: THE WORLD BANK, INTERNATIONAL ECONOMICS DEPARTMENT.

V.6 Sustained Increase in the MUV Deflator

Th2 impact of a 1% sustained increase in prices of manufactured exports as measured by the World Bank's MUV deflator on the iron ore markets is presented in Table 15. The increase in the MUV index is not accompanied by similar increases in the CDP deflators of industrial and developing countries. This scenario does not thus show the impact of an increase of world inflation on the iron ore markets. The MUV deflator is assumed here to have a direct impact on the iron ore reference price. A 1% increase in the MUV deflator is translated into 0.77% increase in the iron ore reference price. Higher iron ore prices cause production to increase and consumption to decline. The production effect ranges from 0.03% in the case of India to 0.72% in the care of Canada. The consumption effect ranges from -1.47% in the case of the Republic of Korea to *-0.04%* in the case of South Africa.

V.7 Sustained Depreciation of the US dollar vis-a-vis the European Currencies and the Japanese Yen

This scenario focuses on the impact of a 33.3% depreciation of the US dollar vis-a-vis the currencies of the Federal Republic of Germany, France, Italy, United Kingdom, the Netherlands, Belgium, Sweden, Spain and Japan on the iron ore markets. The results of this scenario are presented in Table 16. The impact of the US dollar depreciation on the iron ore markets is traced for the first four years, the following four years and the following two years. 1/

1/ Dynamic multipliers that show the impact on the iron ore markets of a 1% depreciation in the US dollar *may* be estimated by dividing the numbers presented in Table 17 by 33.3.

Table 15: DYNAHIC MULTIPLIER ANALYSIS: A SUSTAINED INCREASE IN THE MUV DEFLATOR(IN % P.A.)

COUNTRY	IRON ORE APPARENT CONSUMPTION	IRON ORE PRODUCTION
AUSTRALIA		0.33
BELGIUM	-0.31	
BRAZIL		0.14
CANADA	-0.11	0.72
CHILE		0.39
CHINA	-0.15	
FRANCE	-0.04	
GERMANY, FED. REP. OF	-0.06	
INDIA	-0.47	0.03
ITALY	-0.15	
JAPAN	-0.05	
KOREA, REP. OF	-1.47	
MAURITANIA		0.10
MEXICO		0.23
NETHERLANDS	-0.04	
PERU		0.10
SOUTH AFRICA	-0.04	0.44
SPAIN	-0.22	
SWEDEN		0.21
UNITED KINGDOM	-0.16	
UNITED STATES	-0.62	0.23
	PRICES	
MUV	1.00	
IRON ORE REFERENCE PRICE: BRAZIL/CONTINENTAL EUROPE	0.77	

SOURCE: THE WORLD BANK, INTERNATIONAL ECONOMICS DEPARTMENT.

Table 16: DYNAMIC MULTIPLIER ANALYSIS: A SUSTAINED 33.3% DEPRECIATION OF THE US DOLLAR VIS-A-VIS ALL EUROPEAN CURRENCIES AND YEN (IN % P.A.)

COUNTRY	IRON ORE APPARENT CONSUMPTION (YEARS)			IRON ORE PRODUCTION (YEARS)		
	1-4	5-8	9-10	1-4	5-8	9-10
AUSTRALIA				-0.32	-0.70	0.27
BELGIUM	8.06	14.28	17.98			
BRAZIL				-0.12	-0.29	0.16
CANADA	0.09	0.25	-0.16	-0.66	-1.73	1.72
CHILE				-0.59	-0.61	2.39
CHINA	0.24	0.23	-0.60			
FRANCE	3.09	7.09	5.17			
GERMANY, FED. REP. OF	-3.46	-3.70	-4.56			
INDIA	0.46	1.04	-0.91	-0.03	-0.07	0.11
ITALY	-1.14	-1.04	-3.59			
JAPAN	0.74	0.97	1.10			
KOREA, REP. OF	1.87	1.96	-1.90			
MAURITANIA				-0.11	-0.21	0.28
MEXICO				-0.33	-0.27	0.80
NETHERLANDS	-8.75	-10.28	-11.50			
PERU				-0.04	-0.28	0.08
SOUTH AFRICA	0.02	0.08	0.01	-0.40	-0.77	0.07
SPAIN	0.23	0.56	-1.29			
SWEDEN				-6.72	-10.56	-10.75
UNITED KINGDOM	1.91	3.36	-0.25			
UNITED STATES	0.31	1.38	0.54	-0.04	-0.42	0.47
	PRICE					
IRON ORE REFERENCE PRICE BRAZIL/ CONT. EUROPE	-1.40	-0.40	5.97			

SOURCE: THE WORLD BANK, INTERNATIONAL ECONOMICS DEPARTMENT.

The depreciation of the US dollar makes the cost of iron ore less expensive in terms of the European and Japanese currencies. As a result, apparent consumption increases. Growth in demand for iron ore makes European steel mills amenable to accepting higher iron ore prices. In view of over-capacity and competition among iron ore producers to increase their market share, Brazilian iron ore producers are willing to accept lower iron ore prices for increased exports. Overall, iron ore reference prices decline by 1.4% the first four years. Lower iron ore prices cause production tc decline and consumption to increase.

Some consumer countries find, however, that scrap becomes less expensive than iron ore; they then start substituting scrap for iron ore. As a result, conrumption of iron ore increases less in years 5-8 and much lees in years 9–10. In view of the stance of Brazilian producers and the reduced needs of steel mills, the European negotiators change their position and ask for reductions in iron ore prices. Iron ore prices are agreed to decline by 0.4% in years 5–8. Further reductions in the consumption and production of iron ore cause the European and the Brazilian positions to strengthen. The decline in production in the first eight years affects iron ore prices positively in the last two years of the simulation. Higher iron ore prices cause output to increase in years 9–10.

VI. CONCLUSIONS

This paper has presented the structure of a world iron ore model. Theories of perfect competition and bilateral oligopoly and principles of game theory have been used to determine the price formation of iron ore during contractual negotiations. Model validation showed that the model is suited for policy analysis. Multiplier analysis traced the channels of transmission of exogenous shocks in the iron ore markets. This analysis showed that an increase in Brazilian iron ore capacity will reduce iron pricer, while an increase in EEC crude steel production will increase iron ore prices. Exogenous increases in scrap prices or the MUV index will also tend to increase iron ore prices. The impact of depreciation of the US dollar vis-a-vis the European and Japanese currencies is expected to affect iron ore prices negatively the first eight years and positively the next two years. However, the overall effect is expected to be very small over a ten-year period.

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ANNEX I

INDEX OF VARIABLES

IOPDMC&:	Production, iron ore metal content of country &, th. m. tons, UNCTAD
IOCAPMC&:	Capacity, effective iron ore metal content of country &, th. m. tons, World Bank
IOACMC&:	Apparent consumption, iron ore metal content of country &, th. m. tons, UNCTAD
IOEXURCD&:	Export unit value, iron ore, country &, current dollars, World Bank
IOIMUVCD&:	Import unit value iron ore, country &, current dollars, World Bank
CRSTPD&:	Crude steel production, country &, th. m. tons, UNCTAD, IISI
PTPR/EXUV&:	OPEC petroleum price/export unit value, country &, ratio, World Sank
PK1&:	Investment deflator * (depreciation rate + U.S. treasury bill 3 months) / (1 - corporate tax rate)
IOE/GP&:	Export unit value, domestic currency, iron ore /GDP or CNP deflator, country &, index, World Bank
DPEXWDPI:	Export unit value, domestic currency, iron ore! CPI, country &, index, World Bank
PDHCL:	Metal content (production), country &, %, World Bank
PKI/EXUVDP&:	PK1&/export unit value, iron ore, country &, index, World Bank
D72, D76, D71, D83	Dummies with 1 in 1972, 1976, 1971, and 1983, respectively, and 0 elsewhere
DFPRCDMC2&:	International iron ore price/CPI, country &, index, World Bank
IOUTLMC&:	Utilization rate, country &, iron ore, %, World Bank
IOM&:	Import unit value, iron ore/GDP or GNP deflator, country &, domestic currency, index, World Bank

SCPRDP&:	Scrap price, domestic currency, country &, index, World Bank
IOPRCDMC2&:	Iron ore price, Brazil, 65% Pe, North Port, CIP, $/ton, multiplied by 0.65, World Bank
PIO:	Iron ore price, Brazil, 65% Pe, North Port, CIP, $/ton, World Bank
PBRA:	Desired iron ore EEC price, CIF, $/ton, World Bank
LPIOR2:	Logarithm of product of Brazil production with PIO, mill $, World Bank

COUNTRY CODE (&)

USA:	United Stater
USR:	USSR
DEU:	Germany, Federal Republic of
FRA:	Prance
JPN:	Japan
GBR:	United Kingdom
NDL:	Netherlands
BEL:	Belgium
AUS:	Australia
SWE:	Sweden
ESP:	Spain
ITA:	Italy
IND:	India
BRA:	Brazil
LBR:	Liberia
MRN:	Mauritania
SAF:	South Africa
CAN:	Canada
PER:	Peru
CHL:	Chile
MEX:	Mexico
CHN:	China
KOR:	Korea, Republic of
CSK:	Czechoslovakia

ANNEX II
LIST OF EQUATIONS

2100: IOPDMCCAN = -36.4558 + 1.8049 IOCAPMCCAN
(-3.9403) (8.7185)

\- 22.2363 PTPR/EXUVCAN(-1) t 27.3185 DFEXUVDPCAN
(-4.8433) (2.2011)

R-SQUARED(CORR.): 0.783 SEE: 3.2348 DW: 2.17

PERIOD OF FIT: 1961 1984

F(3, 20): 28.707

DATE OF ESTIMATION: 3/ 3/86

2103: IOPDMCFRA = 2.2397 t 0.3893 IOCAPRCFRA
(0.5666) (1.6528)

\- 1.4103 PTPR/EXUVFRA(-1) - 0.0088 PK1FRA(-1)
(-1.2294) (-0.2540)

\+ 0.4621 IOPDMCFRA(-1)
(2.8079)

R-SQUARED(CORR.): 0.957 SEE: 1.0723 DW: 2.13

PERIOD OF FIT: 1961 1984

F(4, 19): 129.182

DATE OF ESTIMATION: 3/ 3/06

2104: IOPDMCSWE -10.9952 + 0.4169 IOPDMCSWE(-1)
(-1.9388) (1.7762)

\+ 0.9335 IOCAPMCSWE t 0.0197 IOE/GPSWE
(2.2880) (1.7915)

R-SQUARED(CORR.): 0.761 SEE: 1.8960 DW: 1.33

PERIOD OF FIT: 1961 1984

F(3, 20): 25.362

DATE OF ESTIMATION: 3/ 3/86

2107: IOPDHCAUS = -43.2351 t 0.4380 IOPDMCAUS(-1)
(-3.2595) (3.6067)

\+ 0.9695 IOCAPMCAUS + 0.1331 IOE/GPAUS
(4.6061) (2.8790)

R-SQUARED(CORR.): 0.968 SEE: 4.1156 DW: 2.44

PERIOD OF FIT: 1961 1904

F(3, 20): 235.477

DATE OF ESTIMATION: 3/ 3/86

2108: IOPDMCSAF = -7.4603 + 0.4619 IOPDMCSAF(-1)
(-2.1002) (2.8357)

+ 0.6915 IOCAPMCSAF + 0.0227 IOE/GPSAF
(3.2783) (1.9573)

R-SQUARED(CORR.): 0.878 SEE: 1.9436 DW: 1.90

PERIOD OF FIT: 1961 1984

F(3, 20): 56.255

DATE OF ESTIMATION: 3/ 3/86

2109: IOPDMCLBR = -17.0743 + 0.6346 IOCAPMCLBR
(-4.0665) (4.8423)

+ 0.1289 IOPDMCLBR(-1) + 27.1090 PDMCLBR
(0.9844) (4.4812)

+ 4.8073 D72
(4.0385)

R-SQUARED(CORR.): 0.950 SEE: 1.0240 DW: 1.43

PERIOD OF FIT: 1961 1984

F(4, 19): 109.370

DATE OF ESTIMATION: 3/ 3/86

2110: IOPDFCIND = -1.0074 t 1.0160 IOCAPMCIND
(-0.6560) (22.2640)

- 2.5332 PK1/EXUVDPIND
(-0.7696)

R-SQUARED(CORR.): 0.934 SEE: 1.3210 DW: 2.03

PERIOD OF FIT: 1960 1984

F(2, 22): 251.325

DATE OF ESTIMATION: 3/ 3/86

2112: IOPDMCMRN = -0.7818 t 0.8378 IOCAPMCMRN t 0.0980 IOE/GPMRN
(-1.8635) (9.9427) (1.9613)

R-SQUARED(CORR.): 0.890 SEE: 0.68464 DW: 2.06

PERIOD OF FIT: 1960 1904

F(2, 22): 97.981

DATE OF ESTIMATION: 3/ 3/86

2116: IOPDMCBRA = -3.7409 + 0.4794 IOCAPMCBRA + 0.0386 IOE/GPBRA
(-0.6740) (2.0187) (0.5099)

+ 0.5763 IOPDMCBRA(-1)
(.3057)

R-SQUARED(CORR.): 0.957 SEE: 4.6 40 DW: 1.70

PERIOD OF FIT: 1961 1984

F(3, 20): 170.949

DATE OF ESTIMATION: 3/ 3/36

2117: IOPDMCESP = -4.3093 + 1.6956 IOCAPMCESP + 0.0048 IOE/GPESP
(-5.8617) (11.9616) (5.6027)

R-SQUARED(CORR.): 0.3'9 SEE: 0.20543 DW: 1.90

PERIOD OF FIT: 1960 1984

F(2, 22): 137.644

DATE OF ESTIMATION: 3/ 4/86

2125: LN IOPDMCCHL = -0.0064 + 0.4677 LN IOPDMCCHL(-1)
(-0.0091) (2.4446)

- 0.2308 LN PKICHL + 0.3041 LN IOPRCDMC2
(-2.1719) (1.4376)

+ 0.4072 LN IOCAPMCCHL
(1.2975)

R-SQUARED(CORR.): 0.559 SEE: 0.13716 DW: 1.34

PERIOD OF FIT: 1961 1984

F(4, 19): 8.291

DATE OF ESTIMATION: 3/ 3/86

2126: IOPDMCMEX = -1.3626 + 0.7375 IOCAPMCMEX
(-2.0127) (3.5912)

+ 0.3327 IOPDMCMEX(-1) + 0.0639 DFPRCDMC2MEX
(1.9918) (1.8752)

R-SQUARED(CORR.): 0.954 SEE: 0.27232 DW: 1.63

PERIOD OF FIT: 1961 1984

F(3, 20): 1[illegible].593

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2127: IOPDMCPER  =  -0.0600  +  0.3300 IOPDMCPER (-1)
                   (-0.1051)   (2.0153)

                 +  0.6524 IOCAPMCPER  -  0.3864 PTPR/EXUVPER(-1)
                   (3.2567)                (-1.6484)

                 -  1.9366 D76
                   (-4.4562)

                R-SQUARED(CORR.): 0.865    SEE: 0.41080      DW: 2.24

                PERIOD OF FIT:   1961   1984

                F(  4, 19):    37.942

                DATE OF ESTIMATION:  3/ 3/86


2128: IOPDMCUSR  =  -7.0707  +  1.0344 IOCAPMCUSR
                   (-2.4978)   (41.8896)

                R-SQUARED(CORR.): 0.986    SEE:  2.8482      DW: 1.23

                PERIOD OF FIT:   1960   1984

                F(  1, 23):  1754.739

                DATE OF ESTIMATION:  3/ 3/86


2129: IOPDMCCHN  =  -6.8942  +  0.3408 IOPDMCCHN(-1)
                   (-2.7731)   (1.9636)

                 +  0.8046 IOCAPMCCHN
                   (3.9498)

                R-SQUARED(CORR.): 0.947    SEE:  2.2801      DW: 1.97

                PERIOD OF FIT:   1961   1984

                F(  2, 21):   205.324

                DATE OF ESTIMATION:  3/ 3/86


3147: IOPDMCUSA  =  20.1544  +  0.3183 IOUTLMCUSA(-1)
                   (2.3707)    (3.7046)

                 -  9.2276 PTPR/EXUVUSA(-1)  -  22.2385 D82
                   (-1.0087)                   (-3.3935)

                R-SQUARED(CORR.): 0.610    SEE:  5.7476      DW: 2.12

                PERIOD OF FIT:   1961   1984

                F(  3, 20):    13.002

                DATE OF ESTIMATION:  3/ 3/86
```

```
2150: IOACMCCAN  =  -0.4088  +  0.3761 CRSTPDCAN  -  0.0108 IOMCAN
                    (-0.2703)   (2.8563)               (-0.5272)

                 +  0.0132 SCPRDPCAN
                    (0.6054)

                 R-SQUARED(CORR.): 0.567    SEE:  1.6900     DW: 1.78

                 PERIOD OF FIT:    1960   1984

                 F(  3, 21):     11.472

                 DATE OF ESTIMATION:  3/ 4/66
```

```
2153: IOACMCUSA  =  4.0144  +  0.4547 CRSTPDUSA  -  0.3653 IOMUSA
                    (0.3024)    (5.3400)              (-3.1294)

                 +  0.0875 SCPRDPUSA  +  0.2536 IOACMCUSA(-1)
                    (1.3808)             (2.4131)

                 R-SQUARED(CORR.): 0.901    SEE:  4.4574     DW: 2.45

                 PERIOD OF FIT:    1961   1983

                 F(  4, 18):     51.235

                 DATE OF ESTIMATION:  3/ 4/86
```

```
2154: IOACMCDEU  =  -3.8980  +  0.5628 CRSTPDDEU  -  0.0149 IONDEU
                    (-1.44212    (9.5105)              (-0.8230)

                 +  0.0220 SCPRDPDEU  +  0.1587 IOACMCDEU(-1)
                    (3.2054)             (2.9352)

                 R-SQUARED(CORR.): 0.954    SEE:  0.88845    DW: 1.66

                 PERIOD OF FIT:    1961   1984

                 F(  4, 19):    119.263

                 DATE OF ESTIMATION:  3/ 4/86
```

```
2155: IOACMCFRA  =  3.5525  +  0.2701 CRSTPDFRA  -  0.0219 IOMFRA
                    (1.6239)    (2.2471)              (-3.3502)

                 +  0.0076 SCPRDPFRA  +  0.4542 IOACMCFRA(-1)
                    (2.8506)             (4.1884)

                 R-SQUARED(CORR.): 0.854    SEE:  0.86845    DW: 2.32

                 PERIOD OF FIT:    1961   1984

                 F(  4, 19):     34.766

                 DATE OF ESTIMATION:  3/ 4/86
```

```
2157: IOACMCBEL  =  3.7556  +  0.2179 IOACMCBEL(-1)  +  0.4563 CRSTPDBEL
                    (2.8726)   (1.7964)                  (5.5578)

                 -  0.0021 IOMBEL
                    (-4.3546)

                 R-SQUARED(CORR.): 0.863    SEE: 0.86738      DW: 1.85

                 PERIOD OF FIT:   1961   1984

                 F(  3, 20):    49.322

                 DATE OF ESTIMATION:  3/ 4/86


2159: IOACMCGBR  =  0.6007  +  0.5901 CRSTPDGBR  -  0.0825 IOMGBR
                    (0.4413)   (15.6114)            (-1.9788)

                 +  0.0307 SCPRDPGBR  -  0.0956 IOACMCGBR(-1)
                    (2.4114)             (-1.7381)

                 R-SQUARED(CORR.): 0.974    SEE: 0.44341      DW: 1.93

                 PERIOD OF FIT:   1961   1984

                 F(  4, 19):   219.476

                 DATE OF ESTIMATION:  3/ 4/86


2161: IOACMCESP  =  0.5584  +  0.2657 CRSTPDESP  -  0.0002 IOMESP
                    (2.1037)   (4.3111)             (-3.3800)

                 +  0.5460 IOACMCESP(-1)
                    (4.5926)

                 R-SQUARED(CORR.): 0.963    SEE: 0.36006      DW: 2.14

                 PERIOD OF FIT:   1961   1984

                 F(  3, 20):   203.309

                 DATE OF ESTIMATION:  3/ 4/86


2169: IOACMCAUS  =  -1.8527  +  1.2315 CRSTPDAUS  -  5.5405 D83
                    (-1.0552)   (4.5891)             (-2.9788)

                 R-SQUARED(CORR.): 0.620    SEE:  1.7453      DW: 2.12

                 PERIOD OF FIT:   1960   1984

                 F(  2, 22):    20.610

                 DATE OF ESTIMATION:  3/ 4/86
```

```
2175: LN IOACMCSAF  =  -0.1155  +  1.0732 LN CRSTPDSAF
                       (-0.6522)   (11.4697)

                     -  0.0362 LN IOESAF(-1)
                        (-0.4362)

         R-SQUARED(CORR.): 0.892    SEE: 0.15108      DW: 1.87

         PERIOD OF FIT:   1961   1984

         F(  2, 21):    96.149

         DATE OF ESTIMATION:  3/ 4/06


21761 IOACHCIND  =  -3.3423  +  1.5537 CRSTPDIND  -  0.0710 IOEIND
                    (-1.6581)   (3.2726)             (-1.6429)

                  +  0.3679 IOACMCIND(-1)
                     (2.2187)

         R-SQUARED(CORR.): 0,760    SEE:  1.4283      DW: 2.06

         PERIOD OF FIT:   1961   1984

         F(  3, 20):    25.249

         DATE OF ESTIMATION:  3/ 4/86


2182: IOACMCUSR  =  6.8129  +  0.2252 CRSTPDUSR  +  0.6478 IOACMCUSR(-1)
                    (2.6209)   (2.5025)             (5.1562)

         R-SQUARED(CORR.): 0.981    SEE:  2.6818      DW: 2.33

         PERIOD OF FIT:   1961   1984

         F(  2, 21):   579.810

         DATE OF ESTIMATION:  3/ 4/86


2183: IOACMCNDL  =  -0.2405  t  0.4262 CRSTPDNDL  -  0.0017 IOMNDL
                    (-0.6404)   (3.8766)             (-0.3205)

                  +  0.0052 SCPRDPNDL  +  0.2756 IOACMCNDL(-1)
                     (2.7988)             (2.2762)

         R-SQUARED(CORR.): 0.918    SEE: 0.30609      DW: 3.29

         PERIOD OF FIT:   1961   1984

         F(  4, 19):    65.215

         DATE OF ESTIMATION:  3/ 4/86
```

2186: IOACHCKOR = 0.1358 t 0.5942 CRSTPDKOR - 0.0001 IOMKOR
(1.0799) (5.2129) (-4.6837)

+ 0.0000 SCPRDPKOR + 0.3367 IOACMCKOR(-1)
(1.5472) (2.1611)

R-SQUARED(CORR.): 0.988 SEE: 0.29288 DW: 2.57

PERIOD OF FIT: 1961 1984

F(4, 19): 470.055

DATE OF ESTIMATION: 3/ 4/86

2188: IOACMCCHN = 6.5286 + 1.0147 CRSTPDCHN - 0.0655 IOMCHN
(4.4483) (13.7918) (-1.7674)

+ 0.0175 SCPRDPCHN
(1.1295)

R-SQUARED(CORR.): 0.959 SEE: 2.1986 DW: 1.77

PERIOD OF FIT: 1960 1984

F(3, 21): 188.610

DATE Of ESTIMATION: 3/ 4/86

2190: IOACMCITA = -0.5008 + 0.4072 CRSTPDITA - 0.0000 IOMITA
(-1.0307) (11.9561) (-2.7741)

+ 0.0000 SCPRDPITA
(2.8940)

R-SQUARED(CORR.): 0.954 SEE: 0159048 DW: 1.28

PERIOD OF FIT: 1960 1984

F(3, 21): 168.652

DATE Of ESTIMATION: 3/ 4/86

2194: IOACMCJPN = -3.8594 + 0.5617 CRSTPDJPH t 0.0001 SCPRDPJPN
(-0.7916) (6.7391) (0.5935)

+ 0.2945 IOACMCJPN(-1) - 0.0003 IOMJPN
(3.1632) (-0.6578)

R-SQUARED(CORR.): 0.984 SEE: 3.2087 DW: 2.50

PERIOD OF FIT: 1961 1984

F(4, 19): 359,186

DATE OF ESTIMATION: 3/ 4/86

2198: LN IOACMCCSK = 0.6136 + 0.5423 LN CRSTPDCSK
(1.8553) (4.0048)

R-SQUARED(CORR.): 0.914 SEE: 0.58176E-01 DW: 1.93
RHO(1): 0.787

PERIOD OF FIT: 1960 1984

F(1, 22): 244.278

DATE OF ESTIMATION: 3/ 4/86

2400: IOEXUVCDUSA = -11.0329 + 0.6549 IOPRCDMC2
(-5.1736) (5.8343)

+ 0.8589 IOEXUVCDUSA(-1)
(20.9786)

R-SQUARED(CORR.): 0.990 SEE: 2.1641 DW: 1.79

PERIOD OF FIT: 1961 1964

F(2, 21): 1172.136

DATE OF ESTIMATION: 3/ 4/86

2401: IOEXUVCDCAN = -7.3372 + 0.6064 IOPRCDMC2
(-3.2745) (4.7383)

+ 0.6763 IOEXUVCDCAN(-1)
(8.4492)

R-SQUARED(CORR.): 0.957 SEE: 2.5601 DW: 2.11

PERIOD OF FIT: 1961 1984

F(2, 21): 256.410

DATE OF ESTIMATION: 3/ 4/85

2405: IOEXUVCDSWE = -3.0832 t 0.5560 IOPRCDMC2
(-1.8037) (4.4974)

+ 0.4065 IOEXUVCDSWE(-1)
(2.9564)

R-SQUARED(CORR.): 0.910 SEE: 2.0892 DW: 1.34

PERIOD OF FIT: 1961 1984

F(2, 21): 117.515

DATE OF ESTIMATION: 3/ 4/96

2407: IOEXUVCDAUS = -1.1724 + 0.2957 IOPRCDMC2
(-0.9789) (4.2738)

+ 0.6364 IOEXUVCDAUS(-1)
(6.4386)

R-SQUARED(CORR.): 0.930 SEE: 1.4463 DW: 2.33

PERIOD OF FIT: 1961 1984

F(2, 21): 153.043

DATE OF ESTIMATION: 3/ 4/86

2408: IOEXUVCDSAF = -4.0271 + 0.3058 IOPRCDMC2
(-1.9570) (2.9708)

+ 0.7872 IOEXUVCDSAF(-1)
(7.0078)

R-SQUARED(CORR.): 0.888 SEE: 2.5487 DW: 1.96

PERIOD OF FIT: 1961 1984

F(2, 21): 91.919

DATE OF ESTIMATION: 3/ 4/86

2409: IOEXUVCDIND = -1.6742 + 0.2713 IOPRCDMC2
(-1.4439) (3.7139)

+ 0.6597 IOEXUVCDIND(-1)
(6.6200)

R-SQUARED(CORR.): 0.934 SEE: 1.4304 DW: 2.13

PERIOD OF FIT: 1961 1984

F(2, 21): 164.996

DATE OF ESTIMATION: 3/ 4/86

2410: IOEXUVCDBRA = -4.8327 + 0.4444 IOPRCDMC2
(-5.4233) (7.6919)

+ 0.5930 IOEXUVCDBRA(-1)
(9.9931)

R-SQUARED(CORR.): 0.982 SEE: 1.0008 DW: 0.93

PERIOD OF FIT: 1961 1984

F(2, 21): 626.384

DATE OF ESTIMATION: 3/ 4/86

2412: IOEXUVCDUSR = -1.5575 + 0.4252 IOPRCDMC2
(-1.1326) (4.8635)

+ 0.5889 IOEXUVCDUSR(-1)
(5.9770)

R-SQUARED(CORR.): 0.943 SEE; 1.6665 DW: 2.76

PERIOD OF FIT: 1961 1984

F(2, 21): 191.366

DATE OF ESTIMATION: 3/ 4/86

2413: IOEXUVCDVEN = -9.2002 + 0.6538 IOPRCDMC2
(-2.8523) (4.1688)

+ 0.6060 IOEXUVCDVEN(-1)
(5.5348)

R-SQUARED(CORR.): 0.881 SEE: 3.8600 DW: 1.52

PERIOD OF FIT: 1961 1984

F(2, 21): 86.162

DATE OF ESTIMATION: 3/ 4/86

2414: IOEXUVCDCHL = -3.3571 t 0.4213 IOPRCDMC2
(-1.0006) (2.2510)

+ 0.5388 IOEXUVCDCHL(-1)
(3.0754)

R-SQUARED(CORR.): 0.771 SEE: 3.8246 DW: 2.27

PERIOD OF FIT: 1961 1984

F(2, 21): 390717

DATE OF ESTIMATION: 3/ 4/86

2416: IOEXUVCDPER = -3.0418 t 0.3631 IOPRCDMC2
(-1.8511) (3.7165)

+ 0.5801 IOEXUVCDPER(-1)
(5.1597)

R-SQUARED(CORR.): 0.910 SEE: 1.9458 DW: 2.22

PERIOD OF FIT: 1961 1984

F(2, 21): 116.712

DATE OF ESTIMATION: 3/ 4/86

24171 IOEXUVCDLBR = -5.7981 + 0.8272 IOPRCDMC2
(-3.4197) (14.0202)

R-SQUARED(CORR.): 0.891 SEE: 2.1177 DW: 1.67

PERIOD OF FIT: 1960 1984

F(1, 23): 196.565

DATE OF ESTINATIOH: 3/ 4/66

24181 IOEXUVCDHRN -0.2232 + 0.2230 IOPRCDMC2
(-0.0860) (1.8403)

+ 0.6935 IOEXUVCDMRN(-1)
(6.3541)

R-SQUARED(CORR.): 0.829 SEE: 3.1449 DW: 2.19

PERIOD OF FIT: 1961 1904

F(2, 21): 56.935

DATE OF ESTIMATION: 3/ 4/86

2420: IOIMUVCDUSA = -9.1919 + 0.5827 IOPRCDMC2
(-4.3397) (5.2007)

+ 0.8146 IOIMUVCDUSA(-1)
(15.9783)

R-SQUARED(CORR.): 0.984 SEE: 2.1882 DW: 1.30

PERIOD OF FIT: 1961 1984

F(2, 21): 707.852

DATE OF ESTIMATION: 3/ 4/86

2421: IOIMUVCDCAN = -11.6777 + 0.7356 IOPRCDMC2
(-4.2799) (5.0466)

+ 0.8025 IOIMUVCDCAN(-1)
(14.7392)

R-SQUARED(CORR.): 0.983 SEE: 2.7342 DW: 1.99

PERIOD OF FIT: 1961 1984

F(2, 21): 672.352

DATE OF ESTIMATION: 3/ 4/86

```
2422: IOINUVCDDLU  =  -6.0055  +  0.6498 IOPRCDMC2
                      (-2.7378)   (3.9112)

                        +  0.5974 IOIMUVCDDEU(-1)
                           (5.4982)

                 R-SQUARED(CORR.): 0.963    SEE:  2.2487       DW: 1.18

                 PERIOD Of FIT:   1961   1984

                 F(  2, 21):   298.326

                 DATE OF ESTIMATION:  3/ 4/86


2423: IOIMUVCDFRA  =  -6.0571  +  0.7941 IOPRCDMC2
                      (-4.3469)   (7.6535)

                        +  0.3840 IOIMUVCDFRA(-1)
                           (4.5614)

                 R-SQUARED(CORR.): 0.970    SEE:  1.6261       DW: 1.39

                 PERIOD OF FIT:   1961   1984

                 F(  2, 21):   370.721

                 DATE 01 ESTIMATION:  3/ 4/86


2424: IOIMUVCDBEL  =  -7.0167  t  0.6043  IOPRCDMC2
                      (-2.8678)   (3.8593)

                        +  0.5777 IOIMUVCDBEL(-1)
                           (4.9694)

                 R-SQUARED(CORR.): 0.945    SEE:  2.4220       DW: 1.73

                 PERIOD OF FIT:   1961   1984

                 F(  2, 21):   198.555

                 DATE OF ESTIMATION:  3/ 4/86


2426: IOIMUVCDGBR  =  -5.6059  +  1.1128 IOPRCDMC2
                      (-2.0784)   (5.0140)

                        +  0.1740 IOIMUVCDGBR(-1)
                           (1.1012)

                 R-SQUARED(CORR.): 0.909    SEE:  3.1506       DW: 1.09

                 PERIOD OF FIT:   1961   1984

                 F(  2, 21):   115.966

                 .ATE OF ESTIMATION:  3/ 4/86
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2427: IOIMUVCDESP  =  -4.9576  +  0.8973 IOPRCDMC2
                     (-1.8569)    (4.8237)

                   +  0.3753 IOIMUVCDESP(-1)
                      (2.9717)

                R-SQUARED(CORR.): 0.914    SEE:  3.2098      DW: 1.00

                PERIOD OF FIT:   1961   1984

                F(  2, 21):   123.063

                DATE OF ESTIMATION:  3/ 4/86


2429: IOIMUVCDNDL  =  -5.7316  +  0.8045 IOPRCDMC2
                     (-2.6962)    (5.2226)

                   +  0.2838 IOIMUVCDNDL(-1)
                      (2.0679)

                R-SQUARED(CORR.): 0.915    SEE:  2.4825      DW: 1.22

                PERIOD OF FIT:   1961   1984

                F(  2, 21):   125.361

                DATE OF ESTIMATION:  3/ 4/86


2430: IOIHUVCDKOR  =  -8.3223  t  0.7359 IOPRCDMC2
                     (-2.2966)    (3.3861)

                   +  C.4912 IOIMUVCDKOR(-1)
                      (2.7970)

                R-SQUARED(CORR.): 0.838    SEE:  4.1977      DW: 1.64

                PERIOD OF FIT:   1961   1984

                F(  2, 21':    60.497

                DATE OF ESTIMATION:  3/ 4/66


2431: IOIMUVCDCHN  =  -10.6802  +  0.9413 IOPRCDMC2
                     (-7.8263)     (10.4911)

                   +  0.3986 IOIMUVCDCHN(-1)
                      (6.2851)

                R-SQUARED(CORR.): 0.982    SEE:  1.4767      DW: 2.01

                PERIOD OF FIT:   1961   1984

                F(  2, 21):   630.507

                DATE OF ESTIMATION:  3/ 4/86
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2432: IOIMUVCDITA  =  -5.4663  + 0.6585 IOPRCDMC2
                      (-3.1544)  (5.3178)

                      + 0.5207 IOIMUVCDITA(-1)
                        (5.3760)

                R-SQUARED(CORR.): 0.958    SEE:  2.0115      DW: 1.18

                PERIOD OF FIT:   1961   1984

                F(  2, 21):   262.408

                DATE OF ESTIMATION:  3/ 4/86


2433: IOIMUVCDJPN  =  -4.0032  + 0.4500 IOPRCDMC2
                      (-2.9035)  (5.1372)

                      + 0.7209 IOIMUVCDJPN(-1)
                        (10.9588)

                R-SQUARED(CORR.): 0.973    SEE:  1.6875      DW: 1.50

                PERIOD OF FIT:   1961   1984

                F(  2, 21):   416.494

                DATE OF ESTIMATION:  3/ 4/86


2434: IOIMUVCDCSK  =  0.1217  + 0.2926 IOPRCDMC2
                      (0.0632)  (1.9778)

                      + 0.6754 IOIMUVCDCSK(-1)
                        (4.5224)

                R-SQUARED(CORR.): 0.895    SEE:  2.3869      DW: 1.22

                PERIOD OF FIT:   1961   1984

                F(  2, 21):    99.201

                DATE OF ESTIMATION:  3/ 4/86


2909: IOPDMCLBR = 0.1523  + 0.5648 IOCAPMCLBR
                  (0.1200)  (3.0228)

                   + 0.2984 IOPDMCLBR(-1)
                     (1.6034)

                R-SQUARED(CORR.): 0.838    SEE:  1.8375      DW: 1.53

                PERIOD OF FIT:   1961   1984

                F(  2, 21):    60.391

                DATE OF ESTIMATION:  8/29/86
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