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FROM TECHNOLOGICAL DEPENDENCE TO TECHNOLOGICAL DEVELOPMENT: THE CASE OF THE USIMINAS STEEL PLANT IN BRAZIL

VOLUME I

Text: Carl J. Dahlman

Appendices: Fernando Valadares Fonseca
and Carl J. Dahlman

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Carl J. Dahlman and Fernando Valadares Fonseca are Research Fellows with the IDB/ECLA Regional Programme of Research on Science and Technology. They are both based at Fundaçao Centro Tecnológico de Minas Gerais - CETEC - in Belo Horizonte, Minas Gerais, Brazil.

Oficina de la CEPAL en Buenos Aires
Cerrito 264 - 5° piso
1010 Buenos Aires - Argentina

PREFACE

This study is a report on USIMINAS as part of the project "Technological Evolution of the Steel Industry of Minas Gerais: A Micro-economic Analysis" sponsored by the Inter-American Development Bank and the Economic Commission for Latin America through their Regional Program in Science and Technology, and by the Fundação Centro Tecnologico de Minas Gerais with the participation of the State Secretariat of Science and Technology.

The report is the result of several months of research by Carl J. Dahlman, an economist, and Fernando Valadares Fonseca a metallurgical engineer. The first stage consisted of an intensive search and collection of publicly available information on the company. It was the basis for a preliminary volume on the technological evolution of the firm. A second stage, involving a detailed plant visit and collection of information from each of the productive and support sectors was planned, but could not be undertaken. The present volume is an analysis of the firm's technological evolution based on the information collected in the first stage, a short two day plant visit, information provided directly by the firm and a series of interviews with persons inside and outside the firm.

The authors thank the Secretariat of Science and Technology of the State of Minas Gerais, through Drs. JOSÉ ISRAEL VARGAS and OCTÁVIO ELISIO ALVES DE BRITO, for intervention and contacts at the level of State Government and Presidency of the Company. They extend special thanks to CETEC which has provided a base as well as technical, financial and administrative support. In particular they thank Dr JUAREZ TÁVORA VEADO, the Technical Director, for support and encouragement; the Information and Documentation Sector for invaluable assistance in locating and obtaining publications, and CLAUDIO ARAUJO BRANDÃO for the design work.

The authors also thank Dr JORGE KATZ, Coordinator of the BID-CEPAL Program of Research in Science and Technology and Mr. PHILLIP MAXWELL, who is engaged in similar steel studies in Argentina, for support and exchange of ideas and information.

The authors thank USIMINAS for the chance to visit the plant and for the time taken by some of its personnel to discuss various aspects of its development.

Finally, the authors wish to extend special thanks to Dr AMARO LANARI JUNIOR, President of USIMINAS from 1957 to 1975, and to Dr LUIZ VERANO, formerly Superintendent of Operations of the Company, for interviews and invaluable information about the company.

In addition to the main text the present study consists of the six appendices in volume two.

APPENDIX I - The Technology Used by USIMINAS and the Technological Frontier

APPENDIX II - Evolução das Sinterizações da USIMINAS

APPENDIX III - Carvão mineral - Aspectos: Política Nacional, Crises e Efeitos na USIMINAS

APPENDIX IV - Casos Exemplo: Atuação dos Departamentos da Infraestrutura Tecnológica.

APPENDIX V - Evolução da Qualidade dos Laminados da USIMINAS.

APPENDIX VI - Table of Contents of Volumes Resulting from First Phase of Research Study.

Error of fact or misinterpretations remain the sole responsibility of the respective authors and should in no way be ascribed to any of the various institutions involved.

"THE PROCESS OF TECHNOLOGICAL DEVELOPMENT IN SEARCH OF BETTER EFFICIENCY, BETTER QUALITY AND LOWER COSTS IS ESSENTIALLY DYNAMIC, CONTINOUS AND UNDEFINED IN TIME. THAT IS WHY IT DEPENDS ON A PERMANENT VIGILANCE OF MANEGEMENT, AND PRINCIPALLY ON THE AUTHORITY AND LIBERTY OF ACTION OF EACH FOR THE DEVELOPMENT OF FUNCTIONAL RESPONSIBILITY; ON STIMULUS AND MOTIVATION TO OVERCOME THE NEW CHALLENGES WHICH ARE PLACED AFTER EVERY OBSTACLE SURMONTED OR EVERY GOAL ACHIEVED".

Amaro Lanari Junior, 1975

(PRESIDENT OF USIMINAS : 1957-1975)

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CHAPTER ONE

1. INTRODUCTION

This paper is a case study of technical change and technological development in USIMINAS, an integrated steel plant in Brazil. USIMINAS is currently Latin America's largest steel producer. According to Fortune Magazine's listing of the 500 largest non-financial companies outside the United States USIMINAS ranks 308 (1). Figure 1.1 presents a summary series of the main production, financial and technological indexes of the firm. USIMINAS is the sucess story of a Nippo-Brazilian joint-venture. Founded in 1956 it started production in 1962 and under the operational responsibility of the Japanese partners who owned 40% of the stock, it reached planned nominal capacity of 500.000 tons per anum in 1966. Operational responsibility then passed to the Brazilians who had increased their share to about 80%. Over the next six years they increased capacity approximately 140% to nearly 1,200,000 t.a. with basically the original equipment and very little additional investment. Between 1972 and 1976, as a result of a major expansion plan, USIMINAS increased capacity to 2,400,000 t.a.. As of March of this year USIMINAS is producing at the rate of 3,000,000 t.a. and is in the midst of a second large expansion plan which shall increase its capacity to 3.5 M.t.a. (million tons per anum) by next year (2)

Even though USIMINAS is perhaps the most dramatic case, such rapid expansion is not atypical for Brazilian steel firms. COSIPA, which also started out with a capacity of 500.000 tons at about the same time, produced slightly over 1.5 million tons in 1977 and is supposed to reach 3.5 M.t.a. by 1980. The Companhia Siderurgica Nacional (CSN) which started production with an initial capacity of 300.000 t.a. in 1949 produced nearly 2.0M.t.a. in 1977 and is suppo-

(1) Fortune, August, 1978

(2) Such a rapid expansion has been possible, in part, by the tremendous growth of steel demand, particularly in the last 10 years which has resulted from Brazil's rapid industrialization. Between 1968 and 1977 apparent consumption of steel products in ingot equivalents increased from 4,453,000 to 11,163.400 tons.

FIGURE 1.1.

USIMINAS IN NUMBERS 1963-1977

(All value figures in millions of current cruzeiros)

YEAR	77	76	75	74	73	72	71	70	69	68	67	66	65	64	63
1. Production of steel ingots (1000s of ton)	2721	2345	1771	1187	1342	1179	950	850	791	649	570	529	383	276	23
2. Total sales[(a)]	13485	7665	4935	2418	1477	1013	768	505	332	217	144	84	55	27	5
3. Export as a percentage of total sales	na	na	na	na	3	10	5	12	17	19	33	18	39	na	na
4. Cost of Products Sold[(b)]	6525	3820	2882	1468	793	496	399	268	185	140	107	80	44	22	6
5. Cost of Products Sold/total sales (4/2)	48.4	49.8	58.4	60.7	53.7	50.0	52.0	53.1	55.7	64.5	74.3	95.2	80.2	81.5	12[illegible]
6. Gross Profit	6417	3584	1893	665	631	484	236	149	147	76	37	4	10	6	(1)
7. Sales Expenses[(c)]	2338	1104	563	306	197	135	110	75	63	36	24	9	7	3	1
8. General Expenses[(d)]	2526	1339	676	337	130	101	94	69	50	29	44	28	17	20	12
9. Depreciation and Amortization[(e)]	1609	1008	246	141	162	132	36	27	23	11	8	17	-	-	-
10. Other Income (Net)	463	280	130	77	31	63	49	32	40	11	(2)	2	2	2	1
11. Amortization of insuficifient Depreciation	67	134	-	-	-	-	-	-	-	-	-	-	-	-	-
12. Profit before Provisions[(f)]	459	279	538	173	176	182	155	84	30	11	(26)	(45)	(12)	(15)	(13)
13. Net Profit	310	168	409	150	120	128	139	77	28	11	-	-	-	-	-
14. Net Equity	5714	3808	3922	2708	1752	1508	1352	673	655	519	448	125	110	65	20
15. Fixed Assets (total)[(g)(h)]	14961	9504	7827	5107	2926	1873	1281	1186	1096	947	682	175	143	70	43
16. Fixed Productive Assets[(g)(h)] (Excludes capital tied up in expansions but includes acumulated depreciation)	10762	8744	5350	2625	1642	1411	1234	1074	1035	945	682	175	143	39	29
17. K/Q = (16/2)	.80	1.14	1.08	1.09	1.11	1.39	1.61	2.13	3.12	4.35	4.74	2.08	2.60	1.44	
18. $\frac{\text{Net Profit}}{\text{Net Equity}} \times 100$ (13/14 x 100)	5.4	4.4	10.4	5.5	6.8	8.5	10.3	11.4	4.3	2.1	--	-	-	-	-
19. Net Profit / Integrated Capital Cr$	.08	.05	.24	.09	.10	.11	.13	.21	.08	.03	-	-	-	-	
20. Percentage of capital owned by the Japanese (Dec)	17.3	17.3	17.3	18.6	18.7	18.7	20.9	20.9	18.8	18.8	18.8	21.5	21.5	40.0	40.[illegible]

NOTES: a) Total sales includes resale of products imported under CONSIDER import scheme. No dissaggregation was possible.

b) Does not include taxes or depreciation

c) Includes state excise tax (ICM), distribution costs, and others

d) Includes general administrative expenses, financial expenses and others

e) The figures for depreciation are not consistent because USIMINAS changed depreciation practices four times involving changes from straight line to Gaussian to Log Gaussian and back to straight line.

f) This is usually for income tax although in some years provision for doubtful buyers was included here rather than under Sales Expenses

g) Includes Monetary correction and is net of accumulated depreciation

h) Before 1967 no adjustments were made for monetary correction

SOURCES: All information is based on USIMINAS' Annual Reports. Since the presentation of the information varied from year on attempt was made at achieving some consistency when possible. Care should be taken in the interpretation of the results.

FIGURE 1.2

BRAZILIAN STEEL PRODUCTION AND SHARES OF THREE LARGEST PRODUCERS: 1964-1977

(Production in 10^3 tons of steel ingots)
Shares in percentage points

YEAR	Total Brazilian Production	USIMINAS		CSN		COSIPA	
		Production	Share	Production	Share	Production	Share
1977	11,164 (1)	2,721 (1)	24.4	1,962 (1)	17.6	1,540 (1)	13.8
1976	9,229 (2)	2,345 (10)	25.4	1,396 (2)	15.1	796 (2)	8.6
1975	8,307 (2)	1,771 (10)	21.3	1,491 (7)	17.9	789 (7)	9.5
1974	7,502 (13)	1,187 (10)	15.8	1,410 (3)	18.8	754 (3)	10.0
1973	7,149 (13)	1,342 (10)	18.8	1,576 (4)	22.0	609 (4)	8.5
1972	6,512 (13)	1,179 (10)	18.1	1,573 (4)	24.2	687 (4)	10.5
1971	6,010 (13)	950 (11)	15.8	1,553 (6)	25.8	651 (5)	10.8
1970	5,390 (13)	850 (11)	15.8	1,491 (7)	27.7	563 (5)	10.5
1969	4,924 (13)	791 (11)	16.1	1,392 (7)	28.3	551 (5)	11.2
1968	4,450 (13)	645 (11)	14.6	1,330 (7)	29.9	557 (5)	12.5
1967	3,720 (8)	570 (12)	15.3	1,186 (8)	31.9	395 (5)	10.6
1966	3,767 (8)	529 (12)	14.1	1,248 (9)	33.0	431 (5)	11.4
1965	2,977 (8)	383 (12)	12.9	1,256 (9)	42.1	-	-
1964	3.044 (8)	276 (12)	9.1	1,218 (9)	40.4	-	-

SOURCES:

1. IBS-REVISTA, nº 23, (Março-Abril, 1978) p.22
2. CONSIDER-MIC, Relatório Anual 1976, p.8
3. CONSIDER-MIC, Relatório Anual 1975, p.10
4. CONSIDER-MIC, Relatório Anual 1973, p.10
5. COSIPA(Assessoria de Relações Públicas), Catálogo Informativo (Undated), p.10
6. ABM-METALURGIA, nº 175, Vol. 23 (junho 1972) p.461
7. CSN, Relatório Anual 1970, pp. 14-15 (estimated from graphs)
8. CSN, Relatório Anual 1967, p.19
9. RADY, Donald Edmund, Volta Redonda, Albuquerque, New Mexico: Rio Grande Publishing Company, 1973, p.182.
10. USIMINAS, Relatório Anual 1976, p.9
11. USIMINAS, Relatório Anual 1971, p.11
12. USIMINAS, Relatório Anual 1967, p.6
13. Brasil (Convênio Ministério do Trabalho - SIDERBRAS - Serviço Nacional de Aprendizagem Industrial - IBS), A Mão de Obra na Indústria Siderúrgica Brasileira: Características Demanda-Oferta, p.87

FIGURE 1.3

USIMINAS' SHARE IN THE BRAZILIAN SUPPLY

OF NON-COATED FLAT STEEL PRODUCTS BY CATEGORY

YEAR	BRAZILIAN PRODUCTION (1000 of tons of prod)	USIMINAS' MARKET SHARE (%)			
		Non-Coated Flats	Thick Plates	Hot Rolled Products	Cold Rolled Products
1977	3.756 (1)	58 (5)	75 (5)	54 (5)	47 (5)
1976	2.859 (2)	57 (5)	73 (5)	53 (5)	52 (5)
1975	2.653 (3)	52 (5)	72 (5)	46 (5)	42 (5)
1974	2.185 (3)	47 (5)	69 (5)	49 (5)	24 (5)
1973	2.380 (4)	45 (5)	66 (5)	44 (5)	24 (5)
1972	2.239 (4)	43 (5)	53 (5)	42 (5)	24 (5)
1971	1.914 (4)	43 (6)	57 (6)	38 (10)	27 (10)
1970	1.560 (4)	38 (6)	55 (6)	40 (10)	26 (10)
1969	1.527 (4)	32 (6)	51 (6)	33 (10)	23 (10)
1968	1.381 (4)	29 (6)	47 (6)	29 (9)	22 (9)
1967	1.013 (4)	35 (6)	43 (6)	34 (8)	25 (8)
1966	1.145 (4)	27 (6)	47 (6)	27 (7)	12 (7)
1965	953 (4)	19 (7)	40 (7)	7 (7)	1 (7)
1964	780 (4)	18 (7)	38 (7)	-	-

SOURCES:

1. IBS, IBS REVISTA, nº 23, (março-abril 1978) p.24
2. CONSIDER-MIC, Relatório 1976 , p.9
3. CONSIDER-MIC, Relatório 1975 , p.11
4. IBS, 1975 Year Book, p.30 e 31
5. USIMINAS, Relatório Anual 1977, p.12
6. Cota, José Barros, "Alguns Aspectos da Constribuição da USIMINAS para o Desenvolvimento Nacional", USIMINAS Revista, Ano 8, 1977, nº 6, p.76(Data estimated from graph on p.76).
7. USIMINAS, Relatório Anual 1966, p.35;IBS-Year Book, 1975, pp. 30-31 (data subject to revision)
8. USIMINAS, Relatório Anual 1967, p.11-;IBS-Year Book, 1975, pp. 30-31 (Data subject to revision)
9. USIMINAS, Relatório Anual 1972, p.12;IBS-Year Book, 1975, pp.30-31 (Data subject to revision)
10. USIMINAS, Relatório Anual 1973, p.12; IBS-Year Book 1975, pp.30-31

FIGURE 1.4

SOME NOTABLE OPERATIONAL INDEXES ACHIEVED IN USIMINAS BY 1975(*)

SECTOR	INDEX (1)	PERIOD (2)	OBSERVATIONS (3)	COMMENTS
COKE OVENS				
Operating Index (Bat.1 & 2)	171%	1973	400 mm thick ovens	
" " (Bat. 3)	136%	1976*	450 mm thick ovens	
Yield (Coal/coke)	75%	1975		
"Drum Index D.I 150/15	82%	1975		
SINTERIZATION				USIMINAS appears to have the highest productivity index in the world. Next highest found in a 1976 comparison was 41 t/day/m2 for a sinter machine at Dunkerque belonging to USINOR followed by 40.9 t/day/m2 for a machine at Nippon Steel, (1).
Operating index	93%	1975	$90.76 m^2$ grid	
Productivity (machine 1)	49.5 $t/day/m^2$	1973	$190 m^2$ grid	
Productivity (machine 2)	42.0 $t/day/m^2$	1975		
Shater test minimam	88%	1975		
BLAST FURNACES 1 and 2			Ovens with volume of 957 and 885 m3, with out top pressure, av ash content 12.3%	Japan is worlds leader in blast furnace tecnology. Japanese average figures for 49 blast furnaces in operation in 1975 were: internal volume 2425m3, productivity 1.87 t/m3/day, coke rate 440 kg/t, fuel rate 492 top pressure 1 kg/cm2 (2)
Operating index	97%	1973		
Productitity	1,7 t/m3/day	1973		
Coke Rate	438 kg/t	1973		
Fuel rate	490 kg/t	1973		
BLAST FURNACE 3				Japan has most of the new generation>3000 m3 blast furnaces. They averaged productivity 2.25 t/m3/day, coke rate 400 kg/t, fuel rate 490 kg/t, and top pressures of 2-3 kg/cm2 (3)
Operating index	98%	1975	2.700 m3 volume av. ash content 12.5%	
Producting	2.0 t/m3/day	1976*		
Coke Rate	440 kg/t	1975		
Fuel Rate	490 kg/t	1975		
STEEL SHOP Nº 1				In Japan the average tap to tap time was 36 minutes 1971-1973 (4)
Productivity	48 kg/m3/min	May 1972	Steel Shop with three converters	
Runs per day	72	1975		
Tap to tap time	32 min	1972		
Ingot mold consumption	14 kg/t	1975		
ROLLING				In Japan the average yield in slabbing mills was in the order of 92% (5)
Yield slab/killed ingot for strip	86.5%	1974		
Idem semi killed ingot	91.6%	1974		
Idem rimed ingot	90.4%	1974		
Yield thick plate mill	97.3%	1971-1974		
Yield Hot Strip Mill	96.3%	1971-1975		
Yield Cold Strip Mill	97.1%	1973-1975		

* Jan-July 1976

SOURCES: Data or USIMINAS in first four columns is from table on p.7 of 1975 annual report. Since then some indices have improved as will be evident in text. Also, since then USIMINAS has adopted continuos casting in a second steel shop, and has installed a new thick plate mill. The sources for the comments are given in the notes.

NOTES:
1. USIMINAS(II Relatório Conjuntural Siderúrgico Nº 1 (Março 1977) pp. 48-9
2. IBID, p.60
3. IBIDEM
4. IBID, p. 108
5. IBID, p. 127

sed to reach 4.5 M.t.a. by 1980[1].

USIMINAS however is the only one of the three which is on schedule in its expansion plans whereas the other two are one or two years behind. Figure 1.2 shows the evolution of shares in national steel production for the three firms. Notice how USIMINAS' share has increased from 14.1% in its first full year of integrated production to 24.4% at present, while COSIPA's has just increased from 11.4% to 13.8% and CSN's has fallen from 33.0% to 17.6% over the same period. Figure 1.3 gives a finer break-down of USIMINAS' share of Brazilian production of non-coated flat products by major categories. Notice that since 1975 it accounts for more than half of non-coated flat products and that since 1976 it has been responsible for roughly half the production of cold rolled products (which are more processed products.)

USIMINAS is generally considered the most efficient Brazilian producer. A very rough measure of this is its output per man employed in production which has increased from approximately 70 tons per man in 1966 to 228 in 1972 and to 261 in 1977. (see figure 6.1). Figures for Brazil a whole were 113 in 1977.

COSIPA's and CSN's comparable figures for 1976 were 93 and 108 respectively.[2] 1975 figures for the U.S., France, and Japan were 255, 198, and 315 respectively[3]. USIMINAS has also reached international standards in many of its main operational indexes. Figure 1.4 summarizes some of the notable indexes achieved by 1975, commenting on them with respect to international standards when possible.

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(1) USIMINAS, CSN and COSIPA are the three largest Brazilian steel producers. All are majority state owned. They produce all of Brazil's flat products and in 1977 they accounted for 56% of Brazil's total steel production.

(2) This was calculated based on the number of people in the firm working in production in August, 1976. USIMINAS' productivity per man using the some criterion was 255.

(3)USIMINAS, CIT; Relatório Conjuntural Siderurgico, nº 1 (March 1977) p.122

The development of USIMINAS provides a rich case study of technical change in the context of a developing country which could be analyzed from many angles. The two themes around which this study is structured are technical change at the plant level, and the strategy of technological development followed by the firm.

From the point of view of the former one of the most notable features is the tremendous capacity stretching which was achieved with the original equipment and what that has implied for costs. Between 1966 (which was USIMINAS' first year of operation at nominal capacity) and 1972, production of steel ingots increased 123% based essentially on the original equipment. At the same time efficiency in terms of costs, labor productivity and utilization of the capital stock increased significantly. The ratio of costs of production over sales fell from 95.2% in 1966 to 49.0% in 1972. (See row 5 figure 1.1). Over the same period output per man employed at the plant increased from 70 to 228 tons of steel ingots. The capital output ratio fell dramatically from 4.74 in 1967 to 1.39 in 1972 showing a significant increase in the productivity of capital(1) (row 17 figure 1.1). A second notable characteristic is the magnitude of the two subsequent formal expansion plans which involved heavy investments in new capital equipment and structure. The technical changes which were possible with the old equipment as compared to those which dependent on new equipment, the distinction between embodied and disembodied technical change, the exogenous-endogenous character of the change, and the role of formal research activities shall be the central elements of this theme.

(1) The capital measure used was value of fixed investment adjusted for monetary correction net of cummulative depreciation, and net of investment tied up in expansion projects as found in the anual reports. The same series gross of depreciation showed a very similar evolution, falling from 4.83 to 1.52. 1967 was used as a base year because the figures for previous years were not adjusted for inflation in the reports.(See figure 6.5)

In terms of the second theme, USIMINAS has developed a technological strategy which involves combining operational experience, research, engineering, and equipment manufacture, on one hand, and selective purchase of technology complemented by heavy investments in human capital, on the other. In 1968 it began to set up its own research center which is currently the largest and most complete center of its kind in Brazil. In 1971 it created a subsidiary for the manufacture of steel equipment which has now become one of the largest capital goods manufacturers in the country. Also, as a result of its expansion plans USIMINAS has developed a very strong engineering capacity. Although the original plant and the first phase of its first expansion plan were done by the Japanese partners, USIMINAS personel were responsible for 30% of the engineering for the expansion plan to reach 2.4. M.t.a. and 100% of the engineering for the large expansion plan currently under way. It is hard to overemphasize what this means in terms of engineering and technological ability or what it permits in terms of choice and adaptation of imported technology. In addition the firm is selling engineering services and technical assistance to other firms. Currently USIMINAS is doing much the same type of engineering and technical assistance for AÇOMINAS, a new 2 M.t.a. steel plant which is to start operation in 1980, as the Japanese originally did for it less than 20 years ago. This evolution from technological dependence to technology seller is perhaps the most significant indicator of the technological development of the firm. The step by step process through which this capacity was developed the organizational and administrative change which this require and the role of more than 30 million dollars spent on technical assistance contracts and more than 10 million dollars spent on personnel training shall be the main elements of the second theme.

An attempt will be made throughout the study to develop how various specific factors such as initial choice of technology raw materials, financing, general macroeconomic conditions, government intervention in the market, etc. may have affected the technical change and the technological strategy of the firm.

Chapter two is a survey of the main economic literature whose purpose is to place this case study in the context of economic theory and to identify the main issues which will be studied.

Chapter three is a summary history of the development of the Brazilian steel market and of regional rivalries which provides the context for the creation of the firm and explains how technology was obtained through the Japanese.

Chapter four analyzes the steel technology chosen by USIMINAS in relationship to the then current frontier, and explains how the initial choice and type of technology conditions the type of technical change to be expected. It also summarizes the main changes which have occurred in the type of technology used by USIMINAS, analyzing them in terms of the embodiment-disembodiment issue, and dicusses some aspects of the measurement of technical change.

Chapter five covers the development of the steel market in Brazil since the creation of USIMINAS and its effects on USIMINAS' development. After presenting the general context emphasis is given on how the Brazilian steel market crisis of the mid sixties and the increasing government intervention and planning in the market since then have affected the behaviour of USIMINAS.

Chapter six analyses the technical change which has taken place in the firm. A distinction is made between the capacity stretching technical change which took place during the first ten years in the context of the market and an internal financial crises, and the capital intensive type of technical change which characterizes the last six years of operation. Attention is drawn to the possibilities opened up by a large scale expansion, and to the effect of the energy crisis of the seventies on the basic productivity, technological and costs parameters of the firm and the technological response it induces.

Chapter seven develops the role which administrative and organizational changes have played in the technological development of the firm. Special attention is given to the organizational development which was necessary for the capacity, stretching phase and to the development of basic engineering as a response to the needs of the capital intensive expansion. The chapter also focuses on the large amounts of investments in human capital development and in specialized technology contracts which the firm has made, showing how they are part of its overall strategy of technological development.

Finally chapter eight summarizes the implications of some of the aspects of this case study for economic theory and for technological policy at both the firm and the government level.

CHAPTER TWO

2. ECONOMIC THEORY OF TECHNICAL CHANGE AND THE PRESENT CASE STUDY

Technical change has become one of the central themes in the agenda of both developed and developing countries because of the potential it has for increasing output as well as for the implications it has for trade and employment. In the developed countries there is concern about narrowing technological leadership vis a vis other developed countries (and even some advanced developing countries) and on the effect of technology exports on domestic employment (via export displacement or more competitive imports). In the developing countries concern centers on the technological gap with respect to developed countries, and on the most appropriate policies for their own technological development, be it through the importation of technology or its domestic development or both. In this paper because of the case study nature the perspective will be from the point of view of an advanced developing country like Brazil. This chapter provides a quick survey of the main economic literature on technical change, makes a case for microeconomic studies of technical change at the firm level in order to understand more about the process of technical change and the relationship between local efforts in developing countries and the importation of technology, and identifies some of the main economic issues which are to be examined in this particular case study.

2.1. Survey of Economic Literature

Until relatively recently the mains-tream of economic studies focused on the problem of the best allocation of exisiting resources toward the satisfaction of limited wants within a static technologial framework. As observed by Schmookler[(1)] tech-

(1) J. Schmookler, "Technological Change And The Law Of Industrial Growth" in W. Alderson et.al(eds.), Patents And Progress (Homewood, Illinois: Irwin, 1965)

nology was viewed as a parameter like the weather, which effected the outcome of resource allocations but which was not affected by these allocations.

With the interest in growth after world War II a basic concern of economists was to explain the causes for and different rates of growth. Within this context the central idea was to determine to what extent growth was simply the result of an increase in imputs and to what extent it was the result of something else - a residual which was usually attributed to technical change or technological progress. The first studies in this area caused quite a stir in the profession by showing what a small part of productivity growth could be explained by increases in imputs and how much remained as an unexplained residual which was attributed to technical change for lack of better information. This led to a proliferation of aggregate growth studies which have refined the analysis. Even though these models have become increasingly sophisticated they face serious complications which revolve around the problems of specifying the underlying production function to be used and on the measurement and aggregation of imputs and outputs, which, among other things, are related to conceptual issues of what it is that is being measured.(1) The contribution that is eventually

(1) The problem with the specification of the underlying production function to be used has to do with the validity of the restrictive properties which are usually assumed such as unitary or constant elasticity of substitution, type of returns to scale, neutral or non-neutral technical progress and embodied or disembodied technical change. The problems with imputs have to do with the aggregation of non-homogeneous imputs, actual measurement of imputs, adjustments for quality changes and the related question of embodiment. The last two are particularly relevant when trying to separate out the contribution of technical progress as opposed to mere increases in imputs. If imputs are adjusted for quality changes, the contribution of the technical change residual is diminished to the extent that quality changes depend on technical progress. Furthermore, to the extent that technical change is embodied in imputs, the contribution of technical change depends on the substitution of new technologically augmented imputs for older imputs, or in the addition of new imputs. With respect to the specification of outputs a problem is that in an aggregate production function context another factor which may increase total factor productivity is the realloation of resources from industries with low productivity to those with higher productivity (i.e. changes in the composition of output). For a survey of various studies in this area see C. Kennedy and A.P. Thirwal, "Surveys in Applied Economics: Technical Progress" Economic Journal (March, 1972)

attributed to technical progress is heavily dependent on the kind and nature of the adjustments which are made. The crux of the problem is that to make many of these adjustments it is necessary to know more about the relationship between technical change and those other factors, and that micro data on which to base those adjustments is very scarce. Therefore, although the residual approach has been responsible for improving our understanding of the importance of technical change in the growth process, it has not been very enlightening with respect to technical change itself. A clearer understanding of the process of technical change is necessary in order to determine to what extent it is endogenous as opposed to exogenous, what its sources are, and to what extent its rate and direction may be influenced by various factors, including those which are subject to policy control.

At the theoretical level, development in this particular direction has been hampered by the basic conceptualization of technical change within the production function framework and with the usual distinction between a move along a function and a shift in the whole function(1). In the usual conceptualiztion a technology is represented by an isoquant which is a curve ordering techniques which produce the same amount of product, by their relative capital and labor intensities. The assumption behind the curve is that there is substitutability between capital and labor. For analytical convenience it is usually assumed that there are an infinite number of possible capital labor combinations so that the curve is continously differentiable at all of its points(2). A firm will move

(1) This has been convincingly argued in N. Rosenberg, An Assessment of Approaches To The Study of Factors Affecting Economic Payoffs From Technological Innovation. (U.S. Department of Commerce National Technical Information Service Report No PB-245 905, 1975).

(2) Theory also admits the other extreme where there is no substitutability between capital and labor. In this case a technology will be represented by a point in capital labor space and if more than one technology of this type exists the analysis is done in terms of activity analysis such as linear programing.

along such an isoquant curve in reaction to changes in imput prices as it attempts to minimize costs. A technical change is usually represented by an inward shift of the whole isoquant which indicates that as a result of the change less capital and labor imputs are necessary to produce that same given output.[1] Presumably the idea behind the inward shift of a set of isoquant is that underlying knowledge has changed, making all the possible older combinations more efficient such that less imputs are required than at any previous combination of imputs and outputs. This has lead to the implicit assumption that technical change is a matter of major inventions and innovations which presumably shift the whole isoquant curves rather than bending their shape.[2]

(1) These inward shifts need not imply equal proportionate reductions in both imputs thus leading to the concept of factor bias of technical change and its various definitions. A significant body of theoretical literature has developed around the factor bias of technical change.

(2) Another large body of literature has developed around inventions and innovation. In most works the basic idea is that technical change is the result of some sort of formal research. Within this framework the usual imput measures are research and development expenditures or R and D employees, and the usual output measures are number of patents awarded or profitability. Even though there are various problems with measuring both imputs and outputs, not least of which is that formal R and D effort may not be the only source of technical change or that patents and protitability may not be the measures of technical change, there is a general consensus that there is a direct relationship between innovational effort and innovational output although it may depend on factors other than effort and the relationship may not be linear. A large number of studies in this area have focused on what market conditions are most appropriate of the stimulation of technical progress. For excellent surveys of this literature see. M.I. Kamien and N.L. Schwartz, "Market Structure And Innovation : A Survey" (Journal of Economic Literature, 1975); and F. Scherer, Industrial Market Structure And Economic Performance. (Chicago; Rand Mc Nally, 1970) pp. 346-378.

While it may be true that some changes in underlying knowledge may have an effect corresponding to the inward movement of isoquants envisioned in the theoretical representation, it seems that a large part of technological improvement is much more he result of individual changes which affect just a limited portion of the isoquant.(1)

This idea of localized and gradual technical change has been implicitly supported by various studies in what has come to be called the learning literature. These studies have pointed out the role of specific production experience in increasing labor productivity(2). The basic finding is that the amount of labor taken

(1) Rosenberg, Op Cit cites some excellent examples of how improvements depend on continous technological and engineering alterations and adaptations to improve the performance or suit specialized requirements of submarkets and the introduction of other complementary imputs. One is S.C. Gilfian, Inventing The Ship (Chicago: Follet, 1935) that shows the gradual and piecemeal nature of technological change in the shipping industry where it is particularly interesting to follow how much of the technological change consisted of small refinements based on experience and which many times involved adapting improved components or materials developed in other industries. Another is L. Hunter, Steamboats On The Western Rivers (Cambridge: Harvard University Press, 1949) where invention in the formal sense counted far less than a multitude of minor improvements, adjustments and adaptations carried out by anonymous craftsmen, shop foremem and mechanics.

(2) One of the first such studies was T.P. Wright, "Factors Affecting The Cost of Airplanes", Journal of Aereonautica/Sciences (1936) pp.122-128, who pointed out that the number of hours it took to produce airplane bodies was a decreasing function of the total number previously produced. H. Asher "Cost Quantity Relationships In the Airframe Industry"(Santa Monica, California: The Rand Corporation 1956)gives a more detailed survey of the phenomenon in the same industry. W.Z. Hirsch, "Firm Progress Ratios";Econometrica(April, 1956)found a similar phenomeno in the machine tool and textile industry. More recently N. Baloff, " Start-ups in Machine-intensive Production Systems"Journal of Industrial Engineering Vol. XVII (January 1966) and "The Learning Curve: Some Controversial Issues" Journal of Industrial Economics, Vol. XIV nº 3 (July 1966) showed the relevance of learning curves in several highly mechanized manufacturing industries.

to produce a good in various industries is as decreasing function of the total number of goods previously produced. A particularly cited study by Lundberg[1] shows that such results are not necessarily the effect of capital labor substitution for in the Horndal iron works in Sweden output per manhour rose an average of 2% per year even though there was no new investment.

These type of studies led Arrow[2] to advance the hypothesis "that technical change in general can be ascribed to experience, that it is the very activity of production which gives rise to problems from which favorable responses are selected over time."

He developed a simple model in which technical change is fully endogenous, being the by-product of investment. Through it he shows that in such a case the rate of private investment will be less that the social optinum because an act of investment benefits future investors, but the market does not compensate the original investor for that benefit. The model is limited, among other things, by the assumptions that learning takes place only in the capital goods industry, is completely embodied in new capital goods and that no learning takes place in the use of capital goods once they are built which is contrary to evidence such as that of the Horndal effect and more recent learning literature. In addition , as Arrow recognized, he assumed that learning takes place only as a by-product of production whereas in fact learning can be the product of education and research activites specifically oriented to that end.

Somewhat more recently a more developed view of localized technical change which allows specific learning activities undertaken independently of production was introdued by Atkinson and Stiglitz[3]. For them the difference between basic scientific knowledge and technical knowledge is that while the former under-

(1) E. Lundberg, Produktivitet Och Rantabilited (Stockholm: P.A.Nortedt and Soner, 1961)

(2) K. Arrow , "The Economic Implications of Learning By Doing", Review of Economic Studies, June 1962.

(3) A Atkinson and J. Stiglitz, "A New View of Technological Change" Mimiographed version, 1968.

lies a large variety of techniques, the later is related to specific techniques of production. Therefore improvements in one technique will leave others relatively unaffected.[1] Furthermore, while in conventional economic theory the acquisition and transmission of knowledge is assumed to be a costless operation they note that increases in technical knowledge involve either research or experience in production. That "... means that the shift in the production function will be located at the point where the firm or economy is operating now or where it expects to operate in the future". Two immediate consequences are: first, that the set of techniques available at any point in time consists only of techniques currently used or used in the past, so the distinction between movements along and shifts in an a isoquant may be unimportant; and second, that it becomes essential to decide which technique to improve.

Although the first points are not exactly new, its relevance has been emphasized by Rosenberg[2] who has pointed out that actual experience in operating a particular method of production provides signals which direct attention to opportunities for improvements in production techniques which may lead to "compulsive sequences" based on a succession of more or less obvious engineering challenges.Taking a broader perspective David complements this view by emphazising how the actual innovations generated are bound to reflect prior decisions of the firm to operate

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(1) This seems quite an extreme formulation, as it is possible to think of techiques which are applicable in different industries from those in which they were developed, but it serves to emphasize the change of view point regarding the conventional conceptualization.

(2) N. Rosenberg "The Direction of Technological Change: Inducement Mechanisms and Focusing Devices " Economic Development and Cultural Change; Vol. 18 Nº 1, part 1 (October 1969).

at some particular place within the spectrum of techniques. (1)

Even though Atkinson and Stiglitz do not develop their second point much beyond showing why the long term effects of learning from production and investment in R and D affect current decisions as to the level of output and the choise of technique, their approach opens up the idea of planning and explicit technological strategy from the point of view of the firm and of studying how it may be influenced by various micro and macro factors (2).

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(1) P.A. David, Technical Choice Innovation And Economic Growth; (Cambridge: Cambridge University Press, 1975) p.60

(2) Binswanger, "A Microeconomic Approach to Induced Innovation", Economic Journal (December, 1974) for example, has developed a microeconomic model by reformulating innovation possibilities on the basis of alternative research processes which have expected pay-off functions in terms of the efficiency improvements of production factors, and which explicity introduces research cost. Through it he shows how it is neither factor prices nor factor shares which alone influence optimal research mix and hence and biases, but research costs, the expected payoffs to the different types or research (which depend on previous efficiency improvements achieved and the rate of decreasing marginal returns along each research path) and total factor costs as well for they will regulate the amount of the benefits to be obtained. He rejects the idea of any observable technological frontier because any economising unit would spend research resources only up to the point when marginal benfitis equaled marginal costs not to where returns became zero. Furthermore, he points out that a budget constraint on research resources, separate from one on physical investment, does not maximize returns from total investment because rates of return for the two kinds of investment will not necessarily be equal at the margin, and that the form of the budget constraint has a strong influence on the direction of technical change.

Economic theory of technical change is thus moving decisely toward a more microeconomic approach which should be helpful in improving our understanding of the process and in formulating appropriate technological strategies. An important implication of localized technical change from the perspective of developing countries is that research and technical change in advanced countries may not be the most adequate for them given different conditions such as factor prices, climate, raw materials, market size, etc. This means that many technological processes have to be adapted to the specific conditions. Thus, contrary to what has been argued by those who recommend that developing countries leave R and D to developed countries (which presumably have a comparative advantage because their scientific and technological knowledge is more advanced), a case may made for adaptation of imported technology and even outright research and development efforts in the less developed countries themselves. This would be particularly true in areas where there are important differences in primary imputs, scale, or broader social needs.

2.2. Microeconomic Case Studies

To date few empirical microeconomic studies have been done on technical change at the plant level either in developed or in developing countries. One of the few exceptions and so far the most detailed is a study of five Du Pont rayon plants in the U.S. by Samuel Hollander(1) which merits a quick review for the light it sheds on the process and some of the issues which it raises.

(1) S. Hollander, The Source of Increased Efficiency: A Study of Du Pont Rayon Plants (Cambridge: MIT University Press, 1965)

Hollander set out to answer the following broad groups of questions:

1) To that extent could changes in the productivity of the firm's imputs be ascribed to technical change in the narrow sense of costs reductions which are the results of changes in the techniques of production?(1)

2) What was the relationship between scale and technical change?(2)

3) What was the relationship between various changes in technique and investment in plant equipment? To what extent were practicable technical changes dependent on preceding expenditure on plant and equipment, and were these expenditures part of replacement or of expansion programs?

4) Were specific technical changes dependent on formal research activity? Were techniques patented? What was the role of small improvements?(3)

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(1) Hollander chose to consider only the cost reducing aspect of technical change. He was aware that quality improvements were also an objective of technical change, but he did not explicitly include them in this analisys because of the difficulty of obtaining any significant statistical measures for quality improvements.

(2) Implicitly he attributed cost reductions to either technical change or scale effects. To separate out these two he made two types of distinctions. First he distinguished cost reductions which could be attributed to technical change from what he called "plant expansion effects". By the latter he meant "instances of reduction in unit costs resulting from the spreading over a larger volume of output (resulting from plant expansion) of items in total cost which do not increase proportionally with output."Although he noted that it was common in the literature to consider as economies of scale the effects of more efficient equipment and methods introduced at large scale operations, he chose to include such changes within the designation technical change, albeit technical change resulting from the scale of operation. His second distinction was then an attempt to separate out the effects of technical change which were linked to expansion of production from the rest. He thus defined <u>direct</u> technical changes as those which permited the production of given output levels at lower unit costs and thereby reduced unit costs; and <u>indirect</u> technical changes as those which permited production of higher output levels from substantially unchanged plant facilities and complementary imputs.

(3) He made a fundamental distinction between what he termed <u>major</u> and <u>minor</u> technical change. A change was considered major if its development was considered "difficult" to accomplish by men skilled in the pertinent arts before the development program. Major changes usually involved significant departure from existing methods which was one of the reasons why they were difficult to accomplish. A change was considered minor if its development was judged to be a relatively simple process as judged by individuals after the event. Minor change usually involved an evolutionary attention to existing techniques.

The main results of his study were:

1) In all but one of the plants[1] technical change was almost wholly responsible for the net decrease in unit costs. Improvements in imput quality including improved labor and better organization were acknowledged to accounted for part of the cost reductions resulting from technical change, but their contribution was estimated to have been no more than 10%.

2) Technical change which involved an increase in production from substantially unchanged plant facilities and complementary imputs played a more important role in cost reduction than technical changes which permitted the production of given output levels at lower unit cost. This shows that there is an important relationship between technical change and volume of output. It implies that a growing market may be required to stimulate an important portion of improved technology[2]

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(1) The plant for which technical change accounted for less than 85% of total cost reductions was not considered representative in that its construction embodied many cost reducing technical changes which had been introduced in an earlier plant; there fore the effects of cost reducing technical change were not recorded while those of plant expansion were, as the plant was doubled soon after its establishment.

(2) The large role played this type of technical change also implies that it may not be statistically possible to separate out the effects on productivity of increased volume from those of technical change because of their interdependence.

3) Most technical changes required investment in plant and equipment. 80 to 90 percent of the net reduction in unit costs were dependent on investment. However, replacement investment was seen as more important than investment which added to the existing capital stock. Analysis of interplant differentials suggested indirect evidence of the importance of investment for in nearly all cases of delay in the application of existing technology, the main reason was that required investment outlays could not be justified at the time. It was also noted that with relatively small outlays incorporating modifications to existing plants it was sometimes possible to reduce unit almost to the same level as that of newly constructed plants.(1)

The critical role of investment in connection with the implementation of technical change indicates that a lot of technical change is embodied in capital. However, the fact that it was possible in many cases to increase the efficiency of older plants through modifications which required relatively small outlays, means that technological change is not completely frozen in a given vintage. This implies that it is important to pay attention to the rate at which the existing stock of capital is altered to introduce technical change rather than simply to variables which determine the rate of expansion of the capital stock, and that significant modernizations can be accomplished on essentially dated equipment which has important implications for modernization versus rennovation choices faced by the firm.

(1) Similarily, modifications to a plant designed for one product in order to permit the production of a new product were possible with relatively small outlays compared with those required for the construction of an entire new plant.

4) The cummulative contribution of evolutionary changes of existing techniques was usually greater in terms of cost reduction than that of major changes in technique. Hollander noted however that there might be a limit to the potential alterations of existing facilities, and that without some preceding major change the potential stream of minor changes could be exhausted.

5) Patented technology played a very small role in the case of minor technical changes. Most technology was not patented. The bulk was developed at the plants themselves or by the engineering department sometimes in cooperation with the equipment suppliers. Personnel attached to Technical Assistance to Production played the most important role. Major technical changes were mostly dependent on internal formal R and D, although Technical Assistance also contributed substantially. Generally, major process changes were not patented as a whole although individual features were. Some technology was licensed from other companies.

The importance of minor technical changes, which were done mostly internally by Technical Assistante to Production personnel, implies that a lot of what is going on has to do with learning over time.(1) It also implies that close attention should be paid to the various methods companies adopt to exploit minor technical changes, to the relationship between these efforts and those of a research department and to the relation between major and minor changes. It also suggests that organization and the attitude or managers may be very important.

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(1) In fact Hollander states:

> Our study tends to support the view to some extent that a considerable portion of technical change can be ascribed to experience, that is, to the very activity of production which gives rise to problems for which favorable response are selected over time. (p.204)

A major limitation of Hollander's study is to have focused just on cost reducing aspects of technical change.(1) As was shown in Philip Maxwell's (1976) study on a steel plant in Argentina(2) and has been confirmed in other studies undertaken by the BID-CEPAL research program on science and technology in Latin America, technical change has broader objectives than cost reduction. These additional objectives can be sumarized under three broad headings.(3)

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(1) A major criticism to the study in addition to the fact that it focused solely on cost reducing technical change is that it only studies the changes of the productivity of the labor and material component of costs per pound of rayon. It does not comput or control for changes in the amount of capital which the labor and material factors are working with, except to note that investment was generally more of the replacement type than of the substituting type. This seems to be a major omission particularly in light of the importance of investment for the implementation of 80 to 90 percent of all the technical changes It would be useful to know to what extent the improvements were embodied in the capital equipment acquired from the outside as opposed to being a change internal to the firm. Essentially this involves a more careful identification of the nature and sources of technical changes and is something which will be attempted in this study.

(2) P. Maxwell, "Learning And Technical Change In The Steel Plant of Acindar S.A." (Monograph nº 4 of the BID/CEPAL Research Program on Science and Technology: Buenos Aires, 1976)

(3) J. Katz "Cambio Tecnologico, Desarrollo Economico Y Las Relaciones Intra Y Extra Regionales De La America Latina" (CIEPLAN Seminar, Santiago, May 25-27, 1978)has suggested that the broader scope of technical change objectives (i.e less emphasis on cost reduction and more emphasis on product diversification and production increase found in the micro economic studies undertaken by the BID-CEPAL may be associated with the greater protection and greater market concentration in Latin American markets than in the U.S. or Europe.

1) Changes in product mix including introduction of new products, product differentiation[(1)] or quality changes

2) Increases (or decreases) in the capacity of installations[(2)]

3) Changes in imput mix including use of substitutes and imputs of different quality or origin, sometimes for reasons other than costs.[(3)]

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(1) Good empirical examples from the work of the BID-CEPAL program are provided in J. Lucangelli, J. Fidel and P. Shepherd, "Perfil y Comportamiento de La Industria de Cigarillo En Argentina"(Monografia nº 7, Programa BID/CEPAL: Buenos Aires, 1976) on the cigaret industry and G. Vitelli "Competencia, Oligopolio y Cambio Tecnologico En La Industria de La Construccion: El Caso Argentino" (Monografia nº 3, Programa BID/CEPAL: Buenos Aires, 1976) on the construction industry.

(2) For an interesting theoretical piece on capacity stretching as a barrier to entry see R. Levin."Technical Change, Economies of Scale and Market Structure"(PhD Dissertation Yale University, 1974).

(3) One commom example of this in the Latin American context is the substitution of imported for domestic imputs which sometimes takes place even when local prices are higher because of Government legislation (as will be the case in USIMINAS with respect to national coal) or due to greater risk associated with imports under conditions or changing import and tariff barries.

Recently Katz et al[1] studied technical change in an Argentine subsidiary of Dupont which, like Hollanders plants, also produced Rayon. The study shows how the type of technical change which occurs in the plant varies in response to changing external conditions at three levels: the market, the home plant and general macroeconomic conditions.

Initially, as a monopolist well protected from international competition by tariff barries in the order of 200%, and in the context of excess demand, the emphasis of technical change is to increase capacity and to improve the performance of installed capacity. When new firms enter the market and start enlarging their market shares, the emphasis is on improvement of the quality of its products and on diversification of production. During a third period characterized by strong competition by cheaper substitute products (nylon and other synthetic fibers) and rising labor and raw material costs the plant suppresses a labor intensive finishing stage and technical change focuses or reducing raw materials costs through better recovery methods for chemical products and adaptation to use cheaper substitute imputs. It also substitutes capital (which it is able to obtain cheaply second hand from the home company) for labor whose cost has been steadily increasing. As demand displacement by substitute products becames stronger and the firm is forced to operate at sub-optimal scale, the plant develops a new production process to permit the firm to operate profitably at reduced scale which was tradidionally considered anti-economical.

Technical change is conditioned by the firms' relationship to its home plant not only in terms of access to technological innovations developed by the home plant but also in terms of

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(1) J.Katz et al."Productividad Tecnologia y Esfuerzos Locales De Investigacion y Desarrollo" (Monografia Nº 13, BID/CEPAL,1978)

availability of second hand equipment at scrap value which results from the closure of one the U.S. plants and also in terms of the quality of the management it sends to the Argentine plant.

Finally technical change is conditioned by macro elements in that: 1) new legislation which demands shorter working hours in the chemical section of the plant increases labor costs; 2) after 1957 the atmosphese was favorable to factory modernization and the incorporation of new capital equipment from abroad. Combined with the availability of second hand equipment at the home plant this leads to a capital intensive modernization of the plant. Also the availability of cheap well trained Argentina chemical engineers conditions the nature of technical change in that they are absorbed into the firm and capacitate it for a technical change such as developing a production process for small scale operation.

2.3. The Present Case Study

As these examples make clear, in order to understand the process of technical change at the microeconomic plant level it is necessary to broaden the objectives attributed to technical change and to specifically consider how the technical changes taking place within the firm are related to external as well as internal conditioning factors. It is also necessary to explicity consider the technological strategy of the firm. This is an area which has received very little attention in the economics literature. In fact, the technology used by the firm has been virtually ignored. In large part this is because the conventional literature assumes that information is perfect and costless. Thus, the firm which exists in most theoretical models does not have a technological problem. It always knows all about production technology and its improvements. Its problems are usually reduced to output, pricing, and in some more complex cases considerations of quality or product differentiation. With notably few exceptions, economists have made virtually no attempt to study what actually takes place in the black box which transforms imputs into output, how a firm acquires the technology to make that transformation, or how that technology changes and evolves over time.

These issues acquire aditional dimensions in the context of a developing country.

Information is more imperfect and there are generally less persons who have either the technological knowledge of certain production processes or the background to adapt that knowledge to specific conditions or to develop it further. A characteristic of recent technological development in less developed countries is that in large part it is based on the transfer of technological developments which have occurred in more developed countries. This transfer occurs in various ways ranging from direct investment by foreign groups to joint ventures, to purchase of licenses and technological assistance contracts by local groups. In this context it is important to study:

1) how the firm searches for, acquires, implements and develops[(1)] technology;

2) how each of these activities is affected by certain conditions such as original technological profile specific local raw material conditions, development of the world technological frontier local development of the market, and general macroeconomic conditions.

In the present study an attempt is made to use the case of USIMINAS to study various microeconomic aspects of technical change at the plant level and the technological strategy of the firm and of how both may be influenced by various external and internal conditioning factors.

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(1) The bulk of the literature on technological development has focused on the selection of foreign technology and on terms of technology transfer. It is only more recently that there has been an awareness that significant adaptions and improvements are done on imported technologies and that there are even some siginificant local technological developments.

Within the first theme the main issues to be analyzed in this particular case study are:

1) The various objectives of technical change (cost reduction, production increase, product diversification including quality improvements, and imput type or mix changes).

2) The extent to which technical change is dependent on investment, and when so dependent, the degree to which it is embodied in capital goods.

3) The extent to which technical changes embodied in capital goods require scale multiplying plant expansions rather than capacity stretching by changes embodied in complementary equipment.

4) Whether decreasing returns (saturation effects) can be identified within given vintages of equipment.

5) The contribution of technical change efforts realized within the plant versus those due to technology embodied in new equipment, on various productivity parameters.

6) The relationship between technical change and formal research activity as opposed to production experience and routine technical activities.

7) The role of initial technological conditions (equipment and raw materials)in conditioning the technical change path.

Within the second theme the main issues are:

1. How the firm initially obtained the technology necessary for production and how the search for acquisition, implementation and development of technology has changed over time.

2. How various objectives of technical change may have been influenced by conditioning factors at three levels: micro (initial technology chosen, raw materials, various institutional factors - capital goods suppliers), market (evolution and diversification of demand, competition from other producers), and macro (government intervention, exchange rates, tariff barriers, capital incentives, general development of engineering capacity, etc.)

3. What exogenous as opposed to endogenous demands were put on the firm in terms of needs for technical change.

4. What types of organizational changes were made within the firm in order to satisfy those demands.

5. What has been the relationship between internal development versus purchase of technology, how has it changed over time, and what has been the firm's strategy in terms of technological development.

The next chapter will set the stage for the analysis by sumarizing the development of the Brazilian steel industry until the creation of USIMINAS, explaining the context in which it was created, and detailing how and why the Japanese became involved.

CHAPTER THREE

3. HISTORY OF STEEL INDUSTRY AND OF THE CREATION OF USIMINAS

3.1. Short History of the Brazilian Steel Industry Before the Founding of USIMINAS

Iron has been produced in Brazil since 1590 when the first iron works were founded, but steel production did not really start until the beginning of the twentieth century. Domestic steel production was almost neglible through the first two decades. Brazil's growing steel consumption was satisfied through imports. In the period 1908-1912 imports of rolled steel averaged 272,500 tons per year. Even by 1924, the earliest date for which there are systematic figures, production was only 4492.(1) The development of the Brazilian Steel industry since then can be seen in figure 3.1.

By the second half of the 1920s steelmaking began to expand rapidly such that by 1929, 75% of steel ingot consumption was supplied domestically. Nevertheless, steel ingot consumption during the 1920s was only 3-7% of rolled steel product consumption and even by 1929 less than 10% of rolled product consumption was produced domestically.

The growth of iron and steel production in this period was based completely on the initiative of private entrepreneurs. The dominant producer was the firm Queiroz Junior, which was responsible for most of the pig iron production increase in the WWI period.(2)

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(1) Werner Baer, The Development of The Brazilian Steel Industry (Nashville, Tennese :Vanderbilt University Press, 1969) p.57

(2) Ibid, p.58

FIGURE 3.1

BRAZILIAN STEEL, AND ROLLED-STEEL PRODUCTION AND CONSUMPTION, 1920-1967

	STEEL INGOTS			ROLLED-STEEL-PRODUCTS		
YEAR	PRODUCTION	CONSUMPTION	IMPORTS/ CONSUMPTION (%)	PRODUCTION	CONSUMPTION	Imports as a percentage of consumption
1920		14,409	100.0			
1921		7,281	100.0			
1922		5,748	100.0			
1923		4,276	100.0			
1924	4,492	11,697	61.6			
1925	7,559	14,123	46.5	283	373,485	99.9
1926	9,875	15,908	37.9	10,501	399,381	96.0
1927	8,205	14,581	43.7	16,638	435,767	96.2
1928	21,390	28,932	26.1	26,227	483,149	94.6
1929	26,842	35,712	24.8	29,898	514,206	94.2
1930	20,985	24,766	15.3	25,895	259,224	90.0
1931	23,130	24,777	6.6	18,802	143,480	87.1
1932	34,192	36,431	6.1	29,547	165,650	82.2
1933	53,567	56,469	5.1	42,369	277,028	84.7
1934	61,675	65,904	6.4	48,699	343,590	85.8
1935	64,231	69,390	7.4	52,358	345,380	84.8
1936	73,667	80,426	8.4	62,946	386,689	83.7
1937	76,430	85,746	10.9	71,419	505,352	85.9
1938	92,420	101,433	8.9	85,666	355,662	75.9
1939	114,095	120,842	5.6	100,996	429,845	76.5
1940	141,201	147,810	4.5	135,293	414,519	69.4
1941	155,357	159,333	2.5	149,928	368,268	66.2
1942	160,139	161,743	1.0	155,063	262,764	43.3
1943	185,622	189,034	1.8	157,620	325,534	54.9
1944	221,188	259,350	14.7	166,534	492,613	68.1
1945	205,935	233,474	11.8	165,805	465,630	67.5
1946	342,613	378,824	9.6	230,229	656,751	65.4
1947	386,971	431,180	10.2	269,452	738,554	63.8
1948	483,085	492,545	1.9	381,480	567,579	38.2
1949	615,069	625,250	1.6	405,111	698,064	35.7
1950	788,557	803,119	1.8	572,489	843,049	32.6
1951	842,977	871,526	3.3	681,815	1,068,016	36.2
1952	893,300	911,831	2.0	703,105	1,087,934	35.6
1953	1,016,300	-	-	794,460	1,006,821	21.1
1954	1,148,300	-	-	834,037	1,486,411	43.9
1955	1,162,500	-	-	932,283	1,265,659	27.3
1956	1,364,800	-	-	1,073,661	1,324,508	19.1
1957	1,470,000	-	-	1,130 189	1,521,321	25.9
1958	1,659,000	-	-	1,303,633	1,518,146	14.1
1959	1,866,000	-	-	1,492,009	1,998,826	25.3
1960	1,843,019	-	-	1,712,289	2,128,331	20.4
1961	2,443,221	-	-	1,931,785	2,257,701	14.8
1962	2,565,226	-	-	1,998,913	2,275,654	12.4
1963	2,824,045	-	-	2,142,[illegible]00	2,631,700	18.6
1964	3,015,698	-	-	2,108,[illegible]84	2,338,106	11.5
1965	2,982,994	-	-	2,096,[illegible]15	2,305,860	8.6
1966	3,781,797	-	-	2,677,176	-	-
1967	3,696,145	-	-	2,853,177	-	-

SOURCE: Baer, Op. Cit., pp. 61,85

Most of the small iron and steel plants that were set up during the 1920s were constructed by firms whose principal activity was in other fields.

It should also be pointed out that the government encouraged the development of the iron and steel industry. In 1918 and again in 1925 the government passed decrees giving iron and steel producers various types of tax favors, favorable credit, lower freight rates, and import duty exemptions[1].

The decade of the thirties was one of rapid growth in the iron and steel industry. Pig iron production increased almost five times to 160,016 tons in 1939, accounting for virtually all of domestic consumption. Ingot steel production increase slightly more than four times to 114,095 tons, fulling more than 95% of steel ingot consumption. Rolled steel production also increased substantially, rising almost three and one half times and increasing the share of domestic production to almost 25% of consumption.

In Brazil, as in many other Latin American countries, industrial recovery from the world depression of the thirties was rapid. The shortage of imported manufactured goods and strong devaluations made it profitable to substitute previously imported products by expanding domestic industrial production. By 1933 the output of pig iron, steel ingot and rolled products were already higher than the peak of 1929.

During this decade the expansion of one company,

(1) Baer, Op. Cit, p.59

Belgo Mineira, dominated the Brazilian steel industry(1).

In 1936 when pig iron production in Brazil stood at 78.419 tons and steel output production stood at 73,667 tons Belgo Mineira's share with its Sabara plant was 37.6% and 41.8% respectively. In 1940 when total national pig iron output was 135.293 tons and steel output was 141.201 tons, Belgo Mineira, with its Sabara and its New Monlevade plant was producing 62.6% and 60.7% respectively. The dominance of Belgo Mineira was even greater in the production of rolled products. In 1940, its Monlevade plant alone produced 70.6% of the total domestic output of 135.293 tons.(2)

More than ten other steel plants started production in this decade. However, they were largely small because of limited financial means, and were usually located near sources of raw materials or markets.(3) By 1938 the number of blast furnaces in

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(1) Its origins went back to the Companhia Siderurgica Mineira which began production in 1917. In 1921 a Belgian group led by the ARBED (Acieries Reunies de Burbach-Eich-Dulelange) absorved the Companhia Siderurgica Mineira, which then became named the Comnhia Siderurgica Belgo-Mineira. Although the new company was committed to building an integrated charcoal based steelworks at Monlevade, M.G., the construction of that new plant could not be undertaken until 1934 when a rail link from Belo Horizonte was completed. In the meantime Belgo Mineira gradually enlarged the works of the old Mineira company into a small but integrated plant at Sabara by adding a small Siemens Martin steel furnace and a small rolling mill to the already existing blast furnace. Construction of the Monlevade plant started in 1935. By 1940, with the completion of its new rolling mill, Belgo Mineira became Sourth America's largest integrated steel mill, and the world's largest charcoal based integrated stell works. See Baer, Op Cit, pp. 58-9, 68

(2) Baer, Op Cit, p.63

(3) The most important of these was the Usina das Neves of the Groupo Hime

Brazil had increased from 11 in 1930 to 19, all based on charcoal. In that year there were also 23 electric furnaces, four for reduction of pig iron and scrap metal preparation and nineteen for the refining and fusing of steel.(1)

Although the erection of Belgo Mineira's Monlevade plant significantly increased national steel capacity, it was not enough to keep pace with the growing steel needs of the Brazilian economy due to growing industrialization. Furthermore Brazilian plants produced products mainly for light manufacturing and construction;the domestic steel industry did not have the capacity to produce the heavier steels required for the naval industry, railroad rails, flat products, and heavy products for the construction industry. Existing steel companies, with the exception of Belgo Mineira (which was not prepared to expand beyond its Monlevade plant) were generally too small and had no funds for large expansion programs. Also, it was generally felt that the substitution of heavy steel imports could only be achieved through the creation of a large-scale, coke-based, integrated steel plant because Brazil's forest reserves were not adequate to suppy a large-scale charcoal-based steel industry.(2)

(1) Edmund Ray, Volta Redonda,(Albuquerque, New Mexico: Rio Grande Publishing Co.) 197 pp.108-118.

(2) The idea of constructing a large-scale integrated coke-based steel complex was not new. It dated at least back to the pre-WWI period when the government had shown a strong interest in promoting such a steel works financed by foreign capital. After WWI the idea was carried forward by Percival Farquar ,an American entrepreneur who was very active in various large scale undertakings throughout Latin America. Between 1914 and 1939 Farquar presented various plans which combined the export of iron ore with the construction of a large scale integrated steel enterprise. However, for a variety of non-economic factors , which included regional politics, nationalism, and international politics as well as what seems to have been the reluctance of the major sources of foreign finance to disturb the established markets by setting up a steel industry in a steel importing country, all his plans came to no end. See Baer, Op Cit, pp. 69-90 and Charles A. Gould, The Last Titan Percival Farguar, American Entrepreneur in Latin America.

Various other plans were put forward by different groups, and pressure, particularly from the military, increased on the government to develop a large scale steel industry.

Between 1931 and 1937 the Vargas government appointed four successive commissions to study the steel sector. These were the Leite de Castro Commission, (January 1931), the National Steel Commission; (August 1931); the Preparatory Commission for the National Steel Plan, (1934); and the Technical Council of Economy and Finance, (1937). Through these series of commissions it was decided that to enable the private metallurgical sector to continue expanding without damaging competion from the large quasi-government company that was being proposed, it should produce heavy sheet metal, plates, rails and similar goods which where being imported. The mill was to manufacture about 350.000 tons of pig iron per year, and its fuel was to be coke derrived as much as possible from Brazilian coal.[(1)]

A long and intense debate developed as to which foreign group (U.S. or Germany), Brazil should turn to for equipment, financial and technical assistance. This involved not only economic but also political considerations as it took place in the period immediately preceeding and during WWII.[(2)]

The Companhia Siderurgica Nacional, as the company came to be called, was finally founded in April 1941 and located at Volta Redonda in the State of Rio de Janeiro with U.S. assistance. Private U.S. groups initially interested in the project (namely Dupont and

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(1) Ray, Op. Cit, pp. 119-120

(2) For studies of some of the issues and the history of the negotiations see Ray, Op Cit, and Baer, Op Cit, pp. 71-80

United States Steel) had withdrawn[1] but Brazil obtained financial support for the project through the U.S. Export Import Bank.[2] Although the initial idea was to have the company controlled by private Brazilian capital there was trouble in raising that money and for all practical purposes CSN became a Government owned and operated company.

The building of CSN represented a major effort.[3]

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(1) Dupont seems to have withdraw because at the time it was interested nationalistic pressures for a state owned mill were too strong. U.S.S. eventually withdrew citing financial difficulties, pointing out that it had lost its nickel operations with the Russian invasion of Finland and feared making further foreign investments.

(2) The U.S. Export-Import Bank lent Brazil U.S. $20 million for the project in September 1940 under the condition that because of Brazils inexperience in the production of steel on a large basis the management of the firm should include U.S. personnel until to the mutual satisfaction of both parties the firm could be run entirely by Brazilian technicians. Arthur G. Mackee and Co was chosen to design the project and later to help expedite the purchase of necessary machinery.

(3) Wartime conditions in the U.S. and the American Governments priorities of U.S.production efforts which supported the war caused the Brazilians considerable difficulties in obtaining various parts of the equipment on time Equipment price rises caused by war and the increase in transportation costs due to dangers of maritime shipping increased the price of the equipment by about 60%. The construction work which was directed by Colonel Macedo Soares, aided by Brazilian and American consultants, involved 17.000 workers among whom there were 120 engineers and 80 draftsmen. MaKee maintained 12 engineers to assit Macedo Soares in supervising the entire project between 1942-1946. Also, each of the other U.S. firms with whom CSN had subcontracted stationed technical representatives. The total number of engineers and technicians hired by CSN in the U.S. to help build Vólta Redonda was 55. CSN would have liked to hire more, but that was not possible since the U.S. war effort drafted many of them. See Ray, Op. Cit., pp. 154-157.

Figure 3.2 : VOLTA REDONDA'S PRODUCTION AS A SHARE OF BRAZILIAN PRODUCTION 1946-1966

(percent)

YEAR	STEEL	LAMINATED STEEL PRODUCTS
1946	24.9	5.7
1947	37.9	35.0
1948	50.5	52.0
1949	50.1	48.8
1950	53.3	50.2
1951	55.2	50.2
1952	53.3	51.2
1953	47.5	47.3
1954	51.2	50.2
1955	57.3	55.0
1956	54.2	53.9
1957	54.7	52.7
1958	48.9	47.7
1959	46.7	45.0
1960	54.6	41.9
1961	46.2	44.1
1962	45.4	46.8
1963	44.9	47.4
1964	40.4	41.9
1965	42.1	43.9
1966	33.0	35.8

SOURCE: Calculated based on CSN production figures compiled by Rady, Op. Cit., based on CSN anual reports.

Having to procure items during the war meant that there were many delays in filling the orders and in transporting them to Brazil. A lot of improvisation had to be done at the plant site; wrenches belts, shackles, drift pins, etc., were made in the plant's forge and machine shop. Small pony trucks were modified to transport heavy girders or converted into crane trolleys to pull girders into position. In addition many of the machinery arrived without instructions for assembly and set-up. Because of the generally low level of training of the work force, night schools to train workers were conducted fo a six month period in 1942. On the job training was also given in the operation of the mill. The building of Volta Redonda thus also represented a tremendous of mount of investment in human capital which was to be useful for the creation of later Brazilian steel mills.

The creation of Volta Redonda had a marked impact on the production capacity of the Brazilian steel industry. As can be seen in figure 3.2 in 1949 when all sections of the plant were functioning(1) it accounted for half of the total steel ingot and rolled steel production, of the country. Over one third of its output consisted of rails, about one half consisted of sheet metal designed for the manufacture of railway rolling stock, automobiles, trucks and buses. Notice too that as indicated by figure 3.1 with the entrance into production of CSN imports of steel ingots fell from about 10% of total consumption to less than 2% and that imports of rolled steel fell from over 60% to less than 40%.

Another important steel firm which started production in the forties was Acesita (Aços Especiais Itabira) which was devoted.

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(1) Volta Redonda's steel ingot capacity was 270.000 tons when it opened in mid 1946. By 1949 when all section of the plant were functioning steel ingot production was 308.000 tons.

to the production of special quality steel. Although initially set up by private capital(1), as the plant was built more and more financing had to be obtained from the Banco do Brasil such that by 1952 the bank had full control of the company(2).

As can be seen by the production series in figure 3.1, during this decade Brazil reduced imports of steel such that be the end of the decade they were less than 3% of total consumption. In rolled products however, even by the end of the decade imports still acounted for more than one third of consumption.

Throughout the fifties CSN was able to maintain its share of the market at roughly 50% of national production through various expansions, even though steel ingot and rolled steel production increased 136% and 161% respectively during the period 1950 to 1959.The other half of the production increase came from the expansion of the smaller steel producers. As can be seen in figure 3.1., however imports of rolled steel through-out this decade averaged 28% of consumption so was still considerable room for import substituting expansion by domestic producers.

3.2. The Creation of USIMINAS And The Participation Of The Japanese

Minas Gerais, known as the iron heart of Brazil, produced practically 100% of Brazilian iron ore, and was well-endowed with most of the other minerals necessary for steel production excep coal which was only available in the stale of Santa Ca-

(1) Mostly by Percival Farquar

(2) Baer, Op. Cit., p.68

tarina in the south. The creation of a large integrated steel works had been the ambition of the state the for various decade. This ambition suffered a temporary set-back with the location of CSN at Volta Redonda, close to the sea, rather than near the mines in the Iron Quadrilateral of Minas Gerais.

Through disheartened various interest groups in Minas continued making various studies on the feasibility of creating their own plant while they awaited more favorable conditions. In the meantime, industrialists in the state of São Paulo, seeing the success of the CSN and the existence of an easy market represented by the large part of rolled product consumption which was still being imported, decided to create a large integrated plan in their own state as it was the largest consuming market and the industrial center of Brazil. In 1953 a group of Paulista industrialists founded the Companhia Siderurgica Paulista (COSIPA), which was to produce 500.000 t.a. Initially COSIPA was to be a private firm, but as a number of alternative projects were looked into it was soon realized that private capital could not put up the amount of money required, so the State of São Paulo and the Federal Government became involved.(1)

As soon as the State of Minas discovered (January 1956) that the Federal Government was going to participate in COSIPA both directly, and indirectly though CSN, a strong protest was sent to the President of the Republic stating Minas' right to ask for Federal participation in a project of the state. Through such a protest the COSIPA project was temporarily suspended. In the meantime Minas prepared its project for a 500.000 t.a. capacity

(1) The state of São Paulo became a major sharerolder in 1956 to be joinded soon afterwards by the Brazilian National Development Bank (BNDE). The latter eventually became the majority shareholder with 58% versus 23% for the State of São Paulo and 7% for mixed government companies and private groups in 1965

steel plant. On April 16, 1956, this was presented to the newly elected President of the Republic and former governor of the state of Minas Gerais, Juscelino Kubitscheck.President Kubitscheck cooled the regional dispute by offering Federal support to both the Mineiro and Paulista projects on equal footing. To the Mineiros he recommended that they legally incorporate a company so that they could receive Federal aid and cooperation from national and international institutions.

Nine days after the President's statement, with a small, almost symbolic capital equivalent to 50,000 dollars, a group of Mineiros created the Usina Siderurgiga of Minas Gerais (USIMINAS) Its first objective was to promote economic and financial studies necessary to build the firm, and to determine the amount of capital which would be necessary for the undertaking.(1)

Various countries showed strong interest in participating in Brazil's economic development during this period. Germany, France and Italy invited a group of Brazilian engineers and industrialists to visit their countries to learn about their industries. Krupp (Germany), Cresot (France), Oscar Sinigaglia and Corniglian (Italy) were very interested in the USIMINAS project. Krupp wanted to propose a complete turnkey project. Various foreign missions also visited USIMINAS. Three different German groups (Otto Wolf, Salzgitter and Demag) contacted the Board of Diretors about selling equipment. A Checoslovakian mission was interested in financiang equipment in exchange for iron ore. Italy presented a proposal for a steel mill base on electric processes.(2)

(1) The information on the creation of USIMINAS was taken primarily from Jose Dermeval Pimenta. Implantação da Grande Siderurgia em Minas Gerais.(Belo Horizonte, Universidade Federal de Minas Gerais, 1967), which has an excellent collection of original documents.

(2) USIMINAS, Company Anual Reports, 1956-1963 (Belo Horizonte, 1964).

However, the group which ended up participating in the USIMINAS project was the Japanese. At this point Japan was interested in developing the export market for capital equipment in steel. They wanted to show not only the quality of their equipment but also their technological and entrepreneurial capabilities. It seems that at the time USIMINAS was being founded they were looking for a show-case of their equipment and ability. Initially the Japanese were also interested in COSIPA, but negotiations there were already too for advanced with other groups so they focused on USIMINAS[1]. They sent a mission led by Masao Yukawa (Superintén -

(1) Initially the COSIPA project received advisory assistance from the Koppers company of Pittsburg, but in 1959 when the various financial obstacles which had been devaying the construction of the company were finally overcome, COSIPA contracted Kaiser engineers of California as consultants. Kaiser helped the COSIPA engineers to plant the layout of the plant, prepare the overall plan and draw up the list of equipment, although it seems the Kaiser played little or no part in selecting the raw materials, products to be manufactured or the location of the plant as this had already been chosen. Kaiser mainted five engineers in São Paulo during the construction phase (1961-4). In the construction of the plant COSIPA obtained assistance from CSN with cooperation from McKee under a contract for the provison of general advisory assistance. The most important part of CSN's assistance was through the Companhia Brasileira de Projetos Industriais, which was originary CSN's Design Department and later the Engineering Division of CSN before eventually becoming a subsidiary in 1963. COBRAPI was responsible for all the engineering part of the construction. Based on 6000 designs received from Kaiser and equipment suppliers it prepared 5000 additional detail plans for the project, including the layout of the equipment on the site and the civil construction plans with the exception of the calculations of reinforced concrete which were subcontracted to another Brazilian firm. During the construction period COBRAPI maintained 60 to 70 engineers, technicians the planers on the COSIPA project. (See Bruno Leschner, The Transter of Technical Know-How in the Steel Industry in Brazil (New York: UNIDO 1969 pp.69-70) COSIPA's started production late in 1965 rolling ingots and slabs which it obtained from CSN and USIMINAS. It was not until the end of 1965 that all of its sections went into operation.

dent of the National Steel Industries of Japan and member of the National Council of Science). This mission contacted the Directors of USIMINAS and prepared a study on the feasibility of Japanese investment.

As a result of this study, the Japanese government invited a Brazilian technical mission to visit Japan to work out the details of Japanese participation in the project. The mission, which travelled extensively in Japan from August to Setember of 1956, signed a preliminary agreement with the Japanese industrialists who had received them. In principle the agreement called for the creation of a private steel plant with capacity of 500.000 t.a. The Japanese were to contribute 40% of the capital stock and finance the equipment to be purchased from Japan which was estimated at 60% of the total. The Japanese sent a second technical mission composed of engineers and economists which worked with Brazilian counterparts in determining the exacts size and location of the plant. This was followed by a third mission which arrived in April 1957 to complete the preliminary agreements and to set the conditions for the Nippo-Brazilian joint venture. The main points of this agreement , known as the Horikoshi-Lanari Agreement, signed in June 1957, were :[1]

1) Each group's representation on the board of Directors would correspond to its share of the capital stock.
2) Of the five directors, the technical and administrative directors were to be Japanese. The chiefs of such departments were to be chosen by the Japanese, and the sub-chiefs by the Brazilians, or vice-versa. The rest of the personnel, Japanese and Brazilian, was to be chosen seeking the greatest efficiency of the plant's operations and depending on the availability of qualified Brazilian personnel.

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(1) Pimenta, Op. Cit., pp 174-186

3) Forty percent of the capital stock was to be supplied by the Japanese equipment manufactures. The other 60% was to be subscribed by the Brazilian Federal Government through the Banco Nacional de Desenvolvimento Economico, by the State of Minas Gerais, and by various Brazilian companies related to the steel sector.

4) Sixty percent of the equipment credits was to be supplied by the Japanese at 6% for 15 years, with the first three free of interest.

5) Additional financing which became necessary for any reason was to be the responsibility of the Brazilians.

6) Another Japanese mission was to go to Brazil to chose the construction site and to do the detail engineering in cooperation with the Brazilians. A Brazilian mission was to travel to Japan to cooperate with the Japanese technicians in the selection of machinery and equipment. Training of Brazil and Japanese personnel was to be done in Brazilian and Japanese industries.

With respect to the Japanese interest in the USIMINAS project it should be noted that the Japanese cabinet had already agreed on April 12, 1957 that all necessary actions should be taken for the establishement of the Brazilian joint venture. In fact *the project was declared a question of national honor.* In December, 1957 the Japanese steel companies and steel equipment suppliers founded NIPPON USIMINAS LTD, an investment organization created to make the equipment contracts and the financial contracts with Brazilian and Japanese financial sources.

Given the success of the joint venture which resulted it is interesting to speculate why the Japanes were chosen. Although we have not been able to collect any information on the concrete terms of other offers there seem to be at least three main reasons which made the Japanese choice most attractive.

First of all the Japanese equipment credit was offered three percentage points lower that the credit extended by Brazil's own National Economic Development Bank.

Second, the Japanese were not only ready to extend equipment credits, but also to participate in the capital stock. As co-partners the Japanese were assuming responsibility for the effi cient operation of the plant. As already mentioned they were interested not just in making one specific sale of steel equipment but in demonstrating to the world market that they had reached as advanced a technological capability as the U.S., England and Germany- which at that time dominated the market of capital goods for the steel industry. They were thus most interested in making this first large export project a success. This guaranteed the Brazilians that they would really be getting a lot of assistance. Also, it meant that USIMINAS did not have to depend on CSN's technological assistance which given the intense regional rivalries was another advantage

Third, the Japanese and Brazilians were to work closely in teams which offered an excellent learning opportunity for the Brazilians. It seemed implicit in the agreement that the Brazilians were to assume greater responsibility as they developed their capabilities under Japanese training. How clearly defined this was at the beginning is not clear, but that was that effectively happeend as will be seen below.

Through 1958 and 1959 missions from each country flew back and forth establishing operating norms for the implementation of the various aspects of the project including hiring proceedures, equipment purchases, and engineering of the plant. The latter was done in Japan and then discussed with Brazilian technicians before submission to the Board of Directors of the company for approval.

Construction started in 1959 and the first units entered into production in 1962 although the plant was not completely integrated until 1965. We have not been able to determine exactly how much the initial plant cost. The original project called for Cr$ 4.000 million in capital and Cr$ 6.520 million in equipment. However actual costs turned out be much larger than these because of rapid Brazilian inflation betweem the original plans and the actual construction period, and the devaluation of Brazilian currency. As a result the company suffered a severe financial crisis even before it entered into operation. It was solved in part by an increase in the capital stock to Cr$ 18 million in 1962 and eventually to Cr$ 150 million in 1965 and by the extention of more credits. One estimate supplied by the company (1) is that the investment in the initial project for a capacity of 500.000 t.a. was US$ 270 million dollars. It is interesting to note that even though it had been specifically stipulated in the contract that any additional capital which might became necessary was the responsibility of the Brazilians, when they ran into this difficulty and turned to the Japanese, the latter increased their participation to maintain their share at 40% of the capital stock despite the capital expansion, and also ended up financing 80% of the equipment rather than the 60% originally agreed on.

To summarize, USIMINAS was created in a context of strong regional rivalry. As the state of Minas was the producer of iron ore it had always wanted to build a large integrated steel enterprise within its boundaries. However, it lacked coal, capital, and most importantly, the technology for such an undertaking. CSN, the large integrated, state owned, steel enterprise which had been built with Government capital in a state without iron or coal.

(1) USIMINAS: The Company, 1975 company brochure

had already acquired the steel technology necessary for that type of an undertaking through technology contracts mainly with U.S. firms. Nevertheles CSN was already commited to supplying technical assistance to COSIPA which was to be build by Government and private capital in a state which did not have coal or iron, but which was the main steel consuming center of the country. At that point the Japanese entered the scene and offered not only to supply equipment on credit as most other foreign countries were doing, but to participate in the stock (helping to solve part of the capital problem) and to assume initial responsibility for the operation of the firm (solving the technological problem). The advantages offered by this situation were readily perceived by the Mineiros. Having been guaranteed additional financial support by the Government and the State of Minas Gerais, agreements were quickly negotiated and the plant was soon under construction. In fact, USIMINAS started to operate two years sooner than COSIPA which had been founded three years earlier.

USIMINAS thus started out as a joint Nippo-Japanese venture made possible by Minas Gerais' strong interest in having its own large integrated steel plant, and the Japanese interest in setting up a showcase of their equipment and technology in order to enter the world market for steel producing capital equipment which at that time was dominated by U.S., England and Germany.(1)

The Japanese were responsible for the basic, project and detail engineering of the plant as well as for starting production and operating the plant. They were charged with determining all the operating and quality standards as well as the whole administrative system.(2) NIPPON USIMINAS, the Japanese corporation

(1) The Japanese have been very succesful in exporting capital equipment in the steel industry. In Brazil they have a virtual monopoly on imported equipment and during the period 1965-1975 they supplied 50% at all technical assistance to the Brazilian steel industry.

(2) José Barros Cota, "Investimentos em Recursos Humanos Gerenciais na Área Tecnológica e seu Retorno", USIMINAS Revista Ano 7, nº 13, (abril 1976) p.30

grouping the Government and large Japanese steel firms and equipment manufacturers with special interest in USIMINAS, gave technical assistante with the construction, installation and start-up of the plant. That technical assistance was given free of charge until one year after each section had entered into operation.(1) Through 1966 when the technical assistance was completed, 531 japanese engineers and technicians of different degress of specialization passed through USIMINAS with the responsibility of attaining the pre-established indexes and training the Brazilian team.(2)

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(1) Tokinata Takahashi "Multinational Companies and the Iron and Steel Industry: the example of USIMINAS" (Unido Third Interregional Symposium on the Iron and Steel Industry; Brasilia 14-21 October, 1973) UN: ID/WG 146/65 May 1973.

(2) Cota, Op Cit, p. 31

CHAPTER FOUR

4. STEEL TECHNOLOGY AND TECHNICAL CHANGE

Before proceeding to the analysis of further developments of the Brazilian steel market and their effect on USIMINAS it will be fruit ful to make a quick digression on various aspects of steel technology and its developments and their implications for the nature of technical change in the steel industry.

4.1. Steel Technology

The production of steel in an integrated plant consists of three basic transformations. First, the iron contained in mineral ores has to be extracted. This iron is usually found as Fe_2O_3 or Fe_3O_4 in the ore. The first task then is to free the iron from the oxygen. This can be done basically in two different ways. One is to heat the iron ore in a furnace with carbon. At high enough temperatures carbon links up with the oxygen forming CO and CO_2 and producing liquid iron with several impurities. The other is to submit the iron ore to a blast of natural or carbon gas or a solid reductor which links up with the oxygen and yields solid pellets or sponges with up to 90% iron content.[1] The first method can be done by using charcoal or coke based blast furnaces or electric reduction furnaces. The second method, called direct reduction, can be done through a number of processes with different names depending on the reduction agent used.

(1) Blast furnaces produce a liquid product consisting of molten pig iron and slag. Direct reduction, on the other hand, produces a solid product in the form of sponge iron or pellets.

The second transformation involves reducing the carbon content of the pig iron or reduced material produced in the first stage. The basic difference between pig iron and steel is the higher carbon content of the former. The dividing line between the two is usually 2.0% carbon content. The reduction of the pig iron can be done through a number of different methods. The main ones are the open hearth process, the basic oxygen process and the electric arc process.[2]

The third transformation involves turning the steel ingot into a steel product. As a first step the steel ingot is first rolled into a steel slab or a steel block called a bloom or billet depending on its dimensions. After that blooms or billets go through different rolling equipment depending on whether they are to be flat products such as thick plates for ships or sheets for many consumer durables such as cars and appliances; or whether they are to be non-flats such as structural steel, rods, nails, or forged products such as generator shafts, truck axles etc. A relatively recent innovation is continuos casting through which the liquid steel, rather than being poured into ingot molds, goes through a casting machine which allows the first part of the rolling process to be skipped.

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(2) There are important differences among the processes with respect to the change (imputs) they take. The basic oxygen process requires a charge consisting mostly of molten pig iron and little solid scrap iron. The electric arc process takes a mostly solid charge consisting of scrap iron. The open hearth process allows more flexibility in the ratio of the solid scrap to liquid iron. Also, the electric arc process is more limited to relatively smaller scales and is used more for higher quality steels. The choice of process thus depends not only on relative costs, but also or imput availability (namely scrap), the type of steel to be produced, and the scale.

Appendix I describes the technology chosen by USIMINAS with reference to what was available on the technological frontier and sumarizes some of the recent advances in these technologies. USIMINAS chose the then most conventional steel making route for an integrated producer with its planned capacity. This consisted of coke based blast furnaces, oxygen steel converter and conventional rolling from cast ingots.

As noted in the previous chapter, engineering for the plant was done by the Japanese partners who in addition supplied 80% of the equipment. It is hard to speculate how the plant may have been different if some foreign group other than the Japanese had been involved. However, it seems the basic technology would have been the same and that apart from the specific origin, most of the equipment would have been roughly similar.

As emphasized by the perspective of localized technical change the initial choice of technology depends on past technological developments which have shaped the choice set available in the frontier. The specific technology chosen will, in turn, condition the types of changes in the future. While the latter will probally be less true at a more aggregate level since different processes may be developed and the whole frontier may be moving in different directions because of the influence of varying local conditions in worldwide uses, it will be more true at the level of the firm. At least initially the firm will work around the technology it choses. The types of changes will depend both on the type of technology chosen and on various conditioning factors such as initial plant layout and plant bottlenecks, evolution of relative factor and raw material prices and quality, market demands, and new developments at the technological frontier.

In discussing the technological nature of basic production processes Bela Gold[1] has made a very useful distinction between what he calls "capital-dominated", "labor-dominated", and "materials dominated" processes. A "capital dominated" process (e.g. power plants, cement mills) is one in which production workers are engaged mostly in starting, stopping, loading, unloading, setting controls, or in other ways facilitating the functioning of machines and other capital facilities. Materials are merely acted upon by the machine process. A "labor dominated" process (bricklaying, carpentry, custom services) is one where manual efforts and related skills are the core of the production process. Tools and other capital are merely accessories to labor while materials once again have a passive role. In "materials dominated" processes (farming, fishing , smelting) both labor and capital merely facilitate the production capacity determined by materials and related imputs.

In each of these extreme characterizations major advances in the operation of the process as a whole are likely to come from changes in the productivity of the imput characterizing the process.

(1) B. Gold , "A Framework for Productivity Analysis", in S. Eilon, B. Gold and J. Soesan, Applied Productivity Analysis For Industry (Oxford: Pergamon Press, 1972) pp. 33-35.

In terms of the above typology the production of pig iron stage of USIMINAS tends to be mostly of the material dominated type while the production of steel and steel products tend to be mostly of the capital dominated types. A priori it is to be expected that a substantial portion of technical change occuring in the first stage would be related to the control of the physical and chemical properties of the raw materials[1]. In the other two stages it could be expected to depend on the control and programing of the process in order to achieve maximum utilization of the equipment. As will be developed in the next chapter these expectations were confirmed in the case of USIMINAS.

It is important to note that there has been considerable technological development in the process chosen by USIMINAS and that these have also had an impact on the technical change carried out within the firm. As detailed in Appendix I the main developments in each of the processes have been the following:[2]

1. <u>Coke based blast furnaces</u>:
   a) use of auxiary fuels such as oil;
   b) oxygen enrichment of the air;
   c) use of top pressure;
   d) high temperature of the blast;
   e) large size blast furnaces;
   f) continuous charging of large blast furnaces;
   g) equipment for distribution of the charge;
   h) utilization of pressure of furnace gas to run turbines;
   i) computer control.

2. <u>BOF oxygen convertors</u>:
   a) preheating of the solid charge;
   b) use of computer to help control the process;
   c) utilization of LD gases as fuel;
   d) direct computer control of the process.

3) <u>Rolling</u>:
   a) continous casting;
   b) continous mills rather than semi-continous;
   c) computer control.

(1) This tendency would be expected to be even stronger in cases such as USIMINAS' since the technology had been developed abroad where the physical and chemical properties of the raw materials would be most likely to be different.

(2) The main source for these developments was Instituto Chileno Del Acero, <u>Estudio Sobre Technologia En La Industria Siderurgica Latino Americana</u> (Monografia nº 5, BID/CEPAL: Buenos Aires, 1976) pp.29-60.

As noted in Appendix I, USIMINAS has incorporated or is planning to incorporate all of these changes except 1-d; 1-g; 1-h. Some comments on the embodied/disembodied nature of these changes will be helpful for the subsequent analysis. The key point about the embodiment/disembodiment issue would apper to be whether the development can be incorporated into existing equipment or whether it is embodied in new equipment. This is significant in that presumably disembodied technical change is easier to adopt since it could be expected to require a smaller capital out-lay and not do require a scraping or big new expansion decision with all the additional complications either of the latter would involve.

Using this criterion the technical changes listed would be mostly of the disembodied types which is to say that in large part they would be based on or complementary to existing equipment.(1) The two exceptions are large size blast furnaces (which intrinsically require new equipment) and continous casting (which involves skipping the first rolling operations by going directly from liquid steel to a slab rather than passing through the ingot stage).

Three caveats, should be borne in mind in interpreting the analysis of technical change developed in the chapters below. First of all, in general one of the most significant characteristics of technological development in the production of flat rolled products has been an increase in the size of the basic units. It is not only the blast furnaces but also the size of the converters and the capacity of the various rolling equipment that has increased. It is estimated that at present minimum efficient scale for such an integra-

(1) Complementary in the sense of being directly related to the equipment rather than in the sense of not substituting the equipment.

ted plant is in the order of 8 M.t.a[1]. It is that evident that scale related technical change of this type which is strictly capital embodied has played a very important role in the overall development of the industry, particularly in terms of the cost reducing aspects

A second caveat is that in the list above we have considered technical development within a given technological route. There have also been significant technological development in alternative routes such as direct reduction-electric arc steelmaking-continous casting, which seem to be competitive alternatives under certain conditions.[2] Switches to alternate routes would of course represent capital embodied technical change, and in fact the adoption of continous casting is an example of such a shift.

The third caveat is that the list presented above refers just to identifiable technical changes. As was argued before, to a large extent technical change consists of seemingly endless, small and more or less continous adjustments to the existing installations and inumerable variations in raw materials and process control. For the most part these "changes in the small" could be expected to be disembodied.

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(1) A. Cockerill, The Steel Industry: International Comparisons of Industrial Structure and Performance (Cambridge: Cambridge University Press, 1974) pp. 76-85. This is the estimated m.e.s. using the definition of the output level at which unit costs first decrease by less than 5% when further doubled, and it is for a fully integrated flat producer. At one half m.e.s. unit costs increased 13%; at one quarter m.e.s. unit costs increased by 30%.

(2) The Phase IV expansion of the SIDOR Plant in Venezuela (from 1.2 to 4.8 M.t.a.), for example, is based on direct-reduction (using natural gas) - electric arc steel furnaces - continous casting. This will make SIDOR the largest integrated steel plant in the world based on direct-reduction-eletric arc furnace combination.

In the subsequent analysis an attempt will be made to separate out the contribution of embodied versus disembodied technical change on various parameters for the specific case of USIMINAS.

This brings up the difficult issue of how to measure technical change which, as is evident from the discussion in chapter II, demands careful attention.

4.2. The Measurement of Technical Change

In the literature technical change is ofter treated synonymously with productivity increases. The basis for this is probably that since productivity increase may be an effect of technical change, and since it is harder to study technical change itself, productivity increase is used as a convenient proxy. Two points should be made regarding this association. First, technical change does not only have to do with the relationship of any given output and any given imput or group of imputs. It also influences a) the output choice set by making available better quality products or completely different products, b) the imput choice set by allowing substitution in the type and quality or degree of processing of imputs, and c) the process of transforming imputs into outputs itself. Second, productivity may increase for a variety of reasons other than technical change as will be discussed below.

First, a brief note on productivity. Productivity measures usually boil down to an imput-output comparison of one sort or another. At one extreme the so called imput creativity concept compares total output with one imput, and assumes that nothing has happened to the quality or to the nature of the composition of either other imputs or to outputs. At the other extreme the conversion efficiency concept views changes in imput-output adjustments as due solely to changes in the processes which reduce wastage and increase the efficiency with which the process utilizes the potential contribution of imputs assuming that nothing has happened to either the imputs or to the outputs[1].

It is very common to find studies which analyse productivity changes (by extension, technical changes) with these simplistic concepts, particularly by looking at the increased output per unit of a given imput without controlling for either process changes or changes in other imputs. It should also be noted that to make economic sense of productivity and/or technical changes they should be studied within a price framework. It is necessary to know what any given change means in terms not only of how that affects the cost share of that imput in the production process but of the total price effect that it has through its repercussions on the type and mix of other imputs used. In the steel industry it is very common to see lots of studies which focus on how the consumption of coke per ton of pig iron produced falls over time without taking into account that the coke reduction was achieved by a partial shift to oil injection. It is also common to measure productivity and technical progress in terms of output per man hour without taking into account any changes in capital equipment or increased mechanization.

In order to analyze the complex network of imput output relationships which are important for the measurement of both productivity and technical change it would necessary to explicity consider changes at each of the following three levels:

I. CHANGES RELATED TO THE PRODUCTS

Product type
Product quality
Product mix

(1) B. Gold, Op. Cit., pp. 17-19

(2) In reality because of the variation in carbon content in the coke and other fuels the ideal measure should control for the amount of fixed carbon in the fuels.

II. CHANGES RELATED TO THE ACTIVITIES OR PROCESSES OF THE FIRM

Scope of processing activities (make or buy decision)
Nature of production process
Productive capacity of operations
Degree of utilization of capacity
Effectiveness with which operations are integrated

III. CHANGES RELATED TO IMPUTS

Imput type
Imput quality
Imput mix

Changes in the <u>type of product</u> or in the <u>mix of products</u> will result in changes in the productivity of the imputs used to the extent that different types require more or less of different imputs. Likewise, a change in the <u>quality</u> of the product may effect productivity in that it may require different imputs or imputs mixes, or more imputs per unit of output which meets the higher quality standards. Similarly changes in the <u>type of imputs</u>, their <u>quality</u>, or <u>mix</u> may yield more or less output and are thus a source of productivity change. For example, relevant to the present case study, the use of higher quality imported coal with lower ash content reduces the amount of coke needed in the reduction of iron ore into pig iron. Thus a change in the mix of the imputs based on changing the proportions of different quality and types of coal to produce coke will affect the productivity of coke ovens and blast furnaces. This turns out to be not only in terms of more pig iron output per imput of coke, but also in terms of greater pig iron output per unit of blast furnace volume because less volume is occupied by coke and slag and so more iron ore can be smelted in a given heat.

The level of processing activities will also affect productivity. For example, if a steel firm which was originally buying pig iron dedided to integrate backwards into the production of pig iron, a measure such as steel output per employee would show a decline in productivity. However that decline has occurred not because worker productivity in steelmaking has fallen but because of a change in the scope of processing activities. Similar type changes can occur even within just one part of a plant if the degree of processing of the imputs or components which that section receives changes. In considering changes in the nature of the production process a distinction should be made between the optimization of existing processes which involve such things as the timing and speed of the various sequences, imput mix and/or quality of imputs used, reductions in wastage, minimization of down time for maintenance, etc., and changes in the basic nature of the process which usually involve changes in capital equipment, type of imputs used, sequence of activities etc. Changes in the productive capacity of operations can result from changes of the productivity of existing equipment or through the introduction of new equipment. Increases in the productivity of existing equipment is linked to changes in operating conditions, reduction of cycle time, better planning of production runs, closer control of material imputs and timing, and minor modifications in ancillary equipment all of which are related to the optimization of existing processes. Productive capacity of operations can be increased more than proportionally to the increased investment in new equipment to the extent that there are scale effects (either through the duplication of existing equipment, or the purchase of larger equipment units which embody savings in construction or operation) and/or to the extent that acquiring a new piece of equipment, even if it does not involve larger scale, embodies more advanced technology which permits more efficient use of imputs or reduction in operating time.

The degree of utilization of capacity will of course affect the productivity of the underutilized imput and of any fixed complementary imputs. As such changes in utilization will affect productivity measures. However, it must be noted that sometimes changes in utilization depend not only on the aggregate level of demand but also on technical changes which allow a better integration of different facilities in multistage plants where the capacities of the various stages can often be acquired only in lumpy packages.

An issue related to the causes of technical change is its objectives. As should be clear from the previous discussion technical change has a multiplicity of aspects and objectives, even though definitions of, and much of the literature on technical change have glossed over this or focused on some narrow element.

Within the cost-minimizing/profit maximizing structure of production in a competitive environment, one of the main objectives of technical change is to reduce costs per unit of output. This will be related to increasing the productivity of the production process within the context of imput and product prices, and will involve nearly all of the elements of changes possible within a plant presented earlier.

Contrary to the usual theoretical preconceptions of most economists who think in terms of continuous isoquant and constant returns to scale, it would be useful to distinguish an increase in production as a separate objective. Within the framework presented above this can be reflected in 1) an increased utilization of existing capacity which may involve changes in the effectiveness with which operations are integrated, or 2) changes in the productive capacities of existing operations which is related to the nature of existing processes, or 3) expanding capacity through investment in new capital equipment. As pointed out before, this may involve different types of changes depending on whether that new investment consisted of duplicating existing facilities, buying larger units, or buying units which embody more advanced technology. It should be noted that increase in production through any of these means may affect unit costs and thus interact with the first objective.

A separate objective of technical change which should be distinguished is changes in the quality of the product.(1) This is important because many times the product is of too low quality to be accepted by buyers. Conscious efforts to control quality may involve not only changes in the degree of attention paid to the production process, but also of additions of more capital equipment or of the development of new methods of production. It may also be important as a marketing strategy in periods of excess supply or competition from substitute products(2).

Likewise a different objective of technical change is diversification of production. It should be noted that the usual distinction between changes versus process changes which is much cited in the literature represents a conceptual distinction which is hard to find in practice. Usually a change in product or its quality may require a change in the process and a change in process may affect the quality or type of product produced. This is recognized in the steel industry where as pointed out by Gold Peirce and Rossegger.(3)

(1) The importance of quality in the case of steel can be clearly appreciated in the Brazilian case where it is estimated that annual losses caused by corrosion are U.S.$ 4.8 billion (3.5% of GDP)One of the main sectors affected is the automobile industry where the 3 large, state-owned, flat products producers including USIMINAS are the main suppliers.

(2) As was the case in Ducilo Rayon discussed in chapter II. See Katz et al. "Produtividad Tecnologia y Esfuerzos ..."

(3) B.Gold, W. Pierce and G. Rossegger; "Diffusion of Major Technological Innovation In U.S. Iron And Steel Manufacturing", Journal of Industrial Ecomics, 1969-70, p.239.

At least in the iron and steel industry, there is hardly a major process innovation which did not have significant effects on product characteristics. Indeed, recognition of this interaction is institutionalized in the requirement of formal approval by various specification writing agencies for products resulting from new processes.

A fifth objective which may be relevant only in particular settings is reactions to fall in imput quality or availability. In his study of a steel plant in Argentina, for example, Maxwell(1) was given a reaction to fall off in imput quality as a reason for introducing technical changes. In Brazil it is likely that the objective for several technical changes in some of the large coke based plants is to react to the Government requirement that they use 20-40% national coal which is of lower quality and has several undesirable and troublesome characteristics.

At this stage unfortunately, the amount and detail of information which we could obtain for this case study is not sufficient for an analysis of technical change covering all the aspects mentioned. Our data are particularly weak with respect to the evolution of product costs, imput prices, and imput shares. As a result we have been forced to deal with aggregate physical parameters, and in view of that limitation the analysis will be considerably simplified.

Due to the capital domination of the industry we have focused on certain key productivity parameters, which have been disaggregated by main equipment unit in order to try to separate out the contributions of major new units, which may embody

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(1) P. Maxwell, Op. Cit.

technical change, from improvements accomplished through changes with existing units This also has the advantage of permiting an analysis of the changes in each section in order to avoid the problems having to do with scope of activities mentioned above, and to keep track of changes in production process productive capacity and utilization rates. In general we have tried to have 3 different measures: output per employed person, output per some physical measure of the equipment, and output per some principal raw material. These could be considered rough proxies for labor, capital, and material imputs respectively. In addition we have focused principally on the processes up to the production of steel since the rolling stage is more difficult to handle because of the variety of products which can be produced with the same equipment and the degree to which the product mix influences output.

Since our cost data are virtually non existent, implicitly the analysis will be in terms of production increasing technical change. However, when possible, an attempt will be made to point out the influence of or effect on the other objectives, at least in a qualitative way and to discuss important changes related to imputs. The analysis itself will be presented in chapter six. First, however chapter five will present a summary of development in the Brazilian steel market in order to place the technical changes analyzed in chapter six into their proper context.

CHAPTER FIVE

5. DEVELOPMENT OF THE STEEL MARKET AND ITS EFFECTS ON USIMINAS' DEVELOPMENT

The preceeding chapter developed the context in which the firm was created and how it acquired technology. This chapter broadens the analysis to what happened in the market in order to explain some aspects of the microeconomics of the technical change which took place within the firm. The first part explains a market crises which shook the industry in the mid sixties and discusses the recommendations of a government appointed study group. The second develops the increasing government intervention and planning which have came to characterize the industry and affect the behavior of the firms in the sector. The third part traces the development of USIMINAS within this context explaining how the market crisis as well as an internal financial crisis affected the technological strategy of the firm during its first 10 years of operation and how that strategy changed as a result a growing market and the availability of massive amounts of subsidized capital.

5.1. The Market Crisis of The Mid Sixties And The GCIS Report

5.1.1. General Description of the Crisis

In the 1956-1960 period when USIMINAS and COSIPA were being planned the government had thrown aside considerations of inflation and made gigantic public investments, including Brasilia, and major infrastructure development. These all had multiplier effects for other investments. The increase in income also led to increased consumption of durable goods. All of this contributed to a rapid expansion in steel consumption and an average growth rate of 13% per year in steel production.

Figure 5.1

"BRAZIL: PRODUCTION AND APPARENT CONSUMPTION OF STEEL PRODUCTS 1963-1977"

(millions of tons)

YEAR	PRODUCTION				APPARENT CONSUMPTION		
	Total Steel Ingots	Total Rolled	Flat Products	Non-Flat Products	Total Rolled	Flat Products	Non-Flat Products
1963	2.834	2.101	1.029	1.072	2.481	1.319	1.163
1964	3.021	2.236	1.010	1.226	2.374	1.081	1.293
1965	3.003	2.379	1.259	1.119	2.153	996	1.155
1966	3.782	2.953	1.383	1.571	2.830	1.457	1.373
1967	3.734	3.034	1.325	1.709	2.704	1.188	1.516
1968	4.453	3.782	1.788	1.995	3.473	1,697	1.776
1969	4.925	3.905	1.932	1.973	3.821	1.908	1.914
1970	5.390	4.150	1.949	2.201	4.108	2.037	2.071
1971	6.011	4.725	2.302	2.422	5.171	2.692	2.579
1972	6.518	5.302	2.612	2.690	5.573	2.940	2.633
1973	7.149	5.975	2.826	3.149	6.636	3.587	3.049
1974	7.502	6.068	2.637	3.431	9.176	5.260	3.916
1975	8.308	6.721	3.144	3.578	8.599*	4.530*	4.069*
1976	9.169	7.018	3.368	3.650	8.309	4,070	4.239
1977	11.163	8.412	4.474	3.938	9.114	5.076	4.038

Sources: IBS Statistical Yearbooks 1974-1978

* CONSIDER Annual Report 1975

Figure 5.2

BRAZIL: EXPORTS AND IMPORTS OF STEEL PRODUCTS 1963-1977

(1000s of tons)

YEAR	Total Exports of Rolled Products	Exports of Flat Products	Exports of Non- Flat Products	Total Imports of Rolled Products	Imports of Flat Products	Imports of Non Flat Products
1963	-	-	-	381	290	91
1964	42	35	7	218	134	84
1965	166	159	8	191	124	67
1966	108	97	10	255	177	77
1967	285	266	20	262	161	101
1968	190	162	28	289	190	99
1969	216	170	46	328	231	97
1970	382	158	224	496	316	181
1971	172	70	102	789	540	249
1972	272	114	157	713	503	210
1973	267	140	127	1,465	1,157	308
1974	149	40	110	3,946	3,133	813
1975	126	58	68	2,281	1,687	602
1976	140	37	103	1.075	749	326
1977	222	15	207	864	685	179

Source: IBS Statistical Yearbooks 1974-1978

In contrast to the second half of the fifties, the middle of the sixties were marked by a major crisis in the steel sector which eventually led, in the second half of the decade, to the assumptiom of responsibility by the government for the organization and direction of the steel industry.

Starting in 1961 came a period of increasing economic and political instability which led to the end of both foreign and national investment that had been the growth engine of increased steel demand. The deflationary policy started in 1964 did not to much to stimulate investment which was discouraged by a strong increase in takes and monetary contraction. There was stagnation in the consumer market. Basic industries did not receive much government stimulus. The manufacturing industry started to feel the influence of low purchasing power.

The result of this decrease in investment and consumption of durable goods was a crisis in the steel industry. The fall in steel consumption which started in 1964 with a decrease of 4.4% became more pronounced in 1965 when consumption fell 13.2% with respect to 1963 (see figure 5.1). Apparent steel consumption only returned to normal levels in 1968 even though by 1966 a certain improvement was already apparent.

National production during this period did not suffer a significant fall (see figure 5.1). This would seem to imply the apparent stability of the economic capacity of the steel firms. This, however, was not true since it was exactly during this period that USIMINAS, COSIPA, FERRO E AÇO, DE VITÓRIA, and ANHANGUERA began production, at the same time that several expansions were concluded in smaller firms, all of which meant substantial increase in capacity without a corresponding increase in demand. Notice that when looking at a single company such as CSN, (see figure 3.2) which alone accounted for over 40% of production in that period, its output fell in 1964 and did not recover to the 1963 peak until 1967.

In 1966 through an agreement between the Brazilian Government and the World Bank the consulting firm BOOZ ALLEN HAMILTON INTERNATIONAL was asked to do a study of the Brazilian Steel Industry [1]. BAHINT produced a four volume report entitled Brazilian Steel Industry Study. However, because of the seriousness of the steel crisis and some controversy around the recomendations of the study, the Government decided that there was need for greater depth of analysis.

As a result the Government through decree 60642 of April 27, 1967 created a Special Advisory Group on the Steel Industry (Grupo Consultivo da Indústria Siderúrgica-GCIS) to review the BAHINT report and to develop a National Steel Plan.[2]

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(1) The study was carried out by a team of 15 persons. The Americans from BAHINT were responsible for the study but they worked with a group of ten technicians from the state steel producing firms.

(2) Specifically the GCIS was entrusted with the following:

1. An expansion program for the supply of the internal market for the period 1967-71 based on the existing steel plants, as well as the outline of a plan for the five year period, including, if necessary, the creation of new plants.
2. An evalution of the total resources necessary in both national and foreign currencies not only for the initial program, but also for the subsequent expansion, including suggestions on how to obtain these resources.
3. Setting operating standards which would assure the economic equilibrium of the steel companies under the control of the State, and the measures to regulate the financial relationship among the enterprises and between them and the credit granting institutions.
4. Definition of a project for the production of semi-finished steel products destined for the international market as an extension of iron ore exporting activity.
5. Creation of a permanent administrative mechanism or entity in the area of the steel industry for the internal market with the following attributes:
   a) coordinate the execution of programs of expansion assigned to each of the enterprises as well as periodically update such programs;
   b) mobilize and distribute between the enterprises the resources necessary for the realization of the specific programs.
   c) establish directives that would assure the permanent autonomy and equilibrium of each enterprise, including during the period of its recovery.

The fall in apparent steel consumption in the period 1964-1965 was accompanied by a strong increase in exports and a reduction in imports (see figure 5.2).Note that the fall in consumption was more rapid and more drastic for flat products than for non-flats. This was because the demand for non-flats is primarily linked to the construction industry while that for flats is primarily linked to manufacturing industry, and the latter was the first to show signs of retraction. The different reactions of demand for these two classes of products also had significant implications for the state controlled firms versus those controlled privately because virtually all flat production was in the hands of the state while almost all non flats were produced by the private sector.

5.1.2 Analysis of the Crisis

In 1966 the Brazilian Steel Industry was composed of 41 plants controlled by 36 companies producing rolled products foundry products or cast products: (1) These were distributed as follows: fourteen plants belonging to eleven companies were fully integrated, twenty one companies were semi integrated (19 producing rolled steel products, 2 producing foundy items); three compa-

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Footnote (2) continued from previous page

6. Definition of a global policy that would assure the revitalization of the coal economy of the state of Santa Catarina, maintaining the current consumption of metallurgical coal.
7. Any other matters which, at its judgement, were necessary to the full execution of the objectives of the decree.

The CGIS based its analysis on the BAHINT study, the report of a technical group from the Banco Nacional de Desenvolvimento Economico, and, on the various expansion projects presented by the several steel plants.

(1) The five firm concentration ratio was 73%. For comparative purposes the following five firm concentration ratios should be noted: UK, 85%; Belgium, 72%; France, 70%; Japan, 67%; Italy, 60%; U.S., 60%; Germany, 58%. While Brazil was not the most concentrated it was probably more dependent on imports. (CR data from La Convention Etat-Siderurgie La Documentação Français Illustre Nº 22, 1966 .Cited in Plano Siderurgico Nacional, Vol.1 p.2/13.

nies operated four plants producing pig iron or steel for foundry; one non integrated company produced rolled products from billets; the 21/rst plant was being reorganized by the Government. In all a total of thirty one companies produced rolled products with a total installed capacity of 4,640,000 tons of steel ingots.

The State was the majority owner in five of the Companies (CSN, USIMINAS, COSIPA, COFAVI and ACESITA). Whose combined production was 2,740,000 tons of steel ingots or approximately 59% of total installed ingot capacity.(1) The three largest alone accounted for 57% of total installed ingot capacity and produced almost 100% of all flat products, this gave the State virtually complete control of the flat product sector whereas the non-flat sector was almost completely under private control.

Foreign capital participated in six companies operating eight plants with a total production of 580,000 tons of rolled products.(2)

The remaining 25 companies, which were responsible for 27 plants, were owned predominantly by private Brazilian capital and accounted for 420.000 tons of rolled products.(3)

The crisis was the result of a conjunction of various factors. First of all a fall in market demand coincided with a significant expansion of steel capacity with the simulataneous entry of USIMINAS and COSIPA in the flat products sector, and the

(1) In terms of rolled steel products these five state controlled firms produced 1.7 M.t.a. out of a total of 2.7 M.t or approximately 63% of total rolled steel production.

(2) Of the total plants six were dedicated to the production of special steels, one of them producing electric plates for motors.

(3) Two of the plants did not produced rolled products but pig iron for centrifugal tybes.

expansion of various existing plants in the non-flat sector[1]

Secondly a policy of Government price controls which started at the begining of 1965 controlled the price of steel at an artificially low level while the cost of imputs was allowed to increase as a result of rapid general inflation. The deterioration of steel prices with respect to general costs can be seen figure 5.3 below which shows that the wholesale price index increased 33% more than the price of steel products of CSN between 1965 and 31% more than the average price of steel products for Companhia Siderurgica Belgo Mineira (the largest of the non-flat producers). These two companies' experience was typical of that of most steel producers. It should be pointed out nonetheless, that if these two companies which were already well consolidated were in difficult financial shape without even enough wor-

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(1) Back in the fifties when planning was being done for the creation of USIMINAS estimates were that consumption in 1966 was to be somewhere between 2.3 and 2.6 million tons of steel. Projections of expansion of the existing steel plants were that they would be producing 1.8 million tons by 1960. According to Dr Amaro Lanari Junior, who was the representative of the BNDE in the Brazilian economic mission which travelled to Japan in 1957 to work out the USIMINAS agreement with the Japanese, there would therefore be a shortfall of 500.000 tons which was exactly the capacity which the mission was arguing for the USIMINAS plant. Upon questioning by the Japanese, however, Dr Lanari revealed that the 1.8 million production estimate did not include the 500.000 tons of the COSIPA project. The Japanese,nevertheless,decided to participate in the venture. (See Pimenta, Op. Cit.,pp.111-112). On a later ocasion at the meeting on the mining-metallugica problems of Brazil held in April of 1961, Dr Lanari stated that according to the Kafuri Report for COSIPA it was estimated that about 3.5 million tons of steel would be demanded in 1965. That meant, he said, that it was necessary to increase capacity by one million tons. Half of that would be filled by COSIPA, the other half by USIMINAS. Furthermore, he stated that he was not worried about increasing capacity by that much given the rapidly rising of steel consumption which was being experienced in Brazil, and that in case there was any oversupply problem they could always export the excess supply particularly given the current value of the dollar. (Geologia e Metalurgia, Nº 23 (1961) pp. 263- 5)
As will be seen, although the market was in a weak phase in the mid sixties swung to a boom in the seventies.

king capital, the situation was much worse for new plants such as USIMINAS, COSIPA, COMPANHIA FERRO & AÇO DE VITÓRIA and AÇOS ANHANGUERA which had just entered the market precisely the moment when demand was retracting. These new firms were in critical trouble given their financial obligations on the large loans they had taken out for their construction which were supposed to be covered through their operating profits.

Figure 5.3

STEEL AND WHOLESALE PRICE INCREASES 1965-1967

Year/Month	Price of CSN Products	Price of CSBM Products	Wholesale Price Index	C/A x 100	C/B x 100
1965	A	B	C	D	E
January	100	100	100	100	100
June	100	112	111	111	99
December	100	112	125	125	112
1966					
January	110	123	137	125	111
June	110	127	156	142	127
December	121	139	177	146	127
1967					
January	129	149	184	143	123
June	147	149	196	133	131
	-	164	200	-	122

Source: Plano Siderurgico Nacional, Síntese (1969) Table VI p.15 and Table VII p.16

A third cause for the crisis, and related to Government price control was that as part of the Revolutionary Government's general policy of reestablishing realistic prices, import duties on steel imports were reduced. Whereas they had been at an average level of 60% set by Decree Law 3244 of 1957, they were reduced first to an average level of 50% through Decree Law 63 of 1966, and then further to 40% through Decree Law 264 of 1967. Some products, among them a substantial portion the flat products produced by the large three state firms, had import duties reduced from 60% to only 15%.(1)

In general the State firms were harder hit by the crisis than the private firms for a variety of reasons. First of all, the large three flat producers felt the crisis earlier as the demand for flats fell before the demand for nonflats. Second, the simultaneous entry of COSIPA and USIMINAS in the same product line created substantial excess capacity in several types of flat products. Third, the cut-back in production caused by the fall in demand hurt the large flat producers more because most flat products have to be produced a large scale in order to achieve lower unit costs, while the medium and small private firms producing non-flat products had much more flexibility and less rigid cost structures

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(1) The GCIS argued that since most steel products were usually sold at an average level of at least 30% below the internal price of the respective exporting countries, a 15% duty did not offer any effective protection. As a result the GCIS recommended that the low duties be increased to 40% so and that all steel duties be uniformized at that level.

since those products are normally produced in smaller production runs and are subject to less economies of scale. Fourth, the large three flat producers were subject to greater price control than the producers of nonflats. Finally, tariff duties on flat products suffered the greatest reduction.

The deficit forseen by the GCIS for the five State firms for 1967 amounted to 371 million new cruzeiros distributed as follows: COSIPA, 228 million; USIMINAS, 91.7 million; CSN, 42.1 million; COFAVI, 8.2 million; and ACESITA, 1.1 million. The very high deficit for COSIPA was related, on one hand to the fact that the company was operating at less then 70% capacity; and on the other, to the high financial committments it had contracted and to investments still in progress. In spite of the low sale prices USIMINAS had already achieved a situation where gross sales income was almost enough to pay current operating expenses. Its deficit was due mainly to interest and amortization charges on loans taken out for the construction phase. At CSN, which was already well established, sales income was enough to pay operating expenses, but not enough to cover its financial obligations and non-postponeable investments.(1)

With respect to production costs, the GCIS presented a series of observations based on a table prepared by BAHINT which compared Brazil's cost structure with that of Europe and the USA. As can be seen from the table, which is reproduced below, Brazil had a relative advantage in raw materials and in labor. It should be noted, however, that the requirement to use 40% national coal imposed by Government fiat increased costs by more that seven US. dollars a ton - five percent of current sales prices - because not

(1) Approximately one-third of the total deficit corresponded to non-postponeable investments which were necessary for the completion or improvements of the production lines at the enterprises. According to the GCIS's report, the forseen deficit would disappear if the value of sales for the five firms would increase 45% over the sales estimated for the depressed 1967 demand at current prices. Such a high increase in prices would not be necessarry if demand increased to normal levels. Under that hypothesis the GCIS estimated that a real price increase of 25% would be almost enough to permit the companies to wipe out their deificits in 1968. To that end it recommended that the Government authorize such an across-the board price increase over the May 1967 levels.

only was it twice as expensive as imported coal, but of inferior quality. Also, the GCIS pointed out that even though labor costs were a lower percentage of total costs, Brazilian steel firms employed more workers than they actually needed and could reduce labor required per ton of steel even further by operating plants at greater scale. With respect to the item, other costs, which corresponded to electric energy, fuel oil, maintenance, etc.(and had a higher incidence in the Brazilian case), the GCIS doubted that much could be done to reduce it. There was a general impression though, that the item administration and sales could be reduced partly through several rationalization measures but mostly by an increase in the tonnage produced and comercialized. Depreciation and interest were supposedly higher in Brazil because investment costs per ton of steel were higher than in other countries. Neververthless, the GCIS was hopeful that as the plants were expanded,

Figure 5.4

Costs: % Incidence by country or region

COST COMPONENTS	BRASIL	EUROPE	USA
Raw Materials	31	44	37
Labor	10	18	35
Other Costs	22	17	14
Administration and Sales	10	07	05
Depresentation	07	05	05
Interest Payments	11	04	01
Taxes	09	05	03
TOTAL	100	100	100

Source: Programa Siderúrgico Nacional, Plano Siderúrgico Nacional Vol. I, 1967, p.418.

approximating an optimum production capacity, such burdens would be naturally reduced. Finally, with respect to taxes, the GCIS pointed out that the situation in 1967 was different. BAHINT's estimated had been made in 1966 based on the IVC (Imposto de Vendas e Consignações-Tax on Sales and Consignments) which had averaged about 5.5%. However, as a result of a general tax reform, starting at the beginning of 1967, a new tax, the ICM (Imposto de Circulaçao de Mercadorias - Tax on the Circulation of Merchandise) was applied at the rate of 15%. With the addition of the ICM to the old IVC which was named the IPI (Imposto Sobre Produtos Industrializados - Tax on Industrialized Products) the tax burden was more in the order of 20%.

5.1.3. The GCIS Recommendations

According to the GCIS, measures to reduce production costs could be divided into two groups: those dependent on general policies of the Government, and those related to the own organizational and administrative capabilities of the enterprises. With respect to the first group, the GCIS suggested that the Government raise prices, uniformize tariffs eliminate the IPI tax on steel products and lighten the burden of using national coal through the use of a subsidy.

With respect to the second group, the GCIS pointed out the even though these measured depended on the individual enterprises, they were related to the expansion plans and specialization in specific product lines. The GCIS maintained that it would be difficult for the enterprises to make these plans without the intervention of the Government as a catalyzing agent to coordinate production and sales programs and the specialization of producers in order to avoid wasteful duplication and to get the maximum benefits out of the specialization.

The GCIS therefore recommended that a Commission of Steel Development be created (Comissão de Desenvolvimento da Siderurgia) to formulate and implement national steel policy and establish the necessary coordination of the investment plans of both the private and state firms in the sector.(1) In addition, the GCIS pointed out that in 1967 the Government had majority control of five firms which together represented 63% of the steel production of the country and an investment valued at three billion new cruzeiros. Further, it emphasized that while the Government had taken the initiative only in the creation of CSN and what while only in the case of USIMINAS among the rest has it started out with the majority of capital, it had been forced to assume majority ownership of the others because the private sector had not been able (or willing)(2) to raise the amount of capital required for such an enterprise. It pointed out that the joint administration of the five state enterprises would permit the coordination of production, sales and investment programs which could bring significant resource savings and reduction in costs. Therefore, it recommended that the five state firms be incorporated into a state holding company - to be called BRASSIDER - with the purpose of assuring the improment of efficiency in those firms through coordination of their investment, production and commercialization plans.(3)

With respect to the elaboration of a National Steel Plan the GCIS projected the demand of rolled steel products on a

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(1) The CDS was to be presided by the Minister of Industry and Commerce and integrated by the Minister of General Planning and Development; The Ministers of State, Mining and Energy, Transport; The Chiefs of Staff of the Armed Forces, The Presidents of the BNDE, BRASSIDER, and IBS; and a General Secretary. As will be seen below, the Government created, a steel council in 1968, but it was not until 1970 that it gave it the structure and representation suggested in the GCIS report.

(2) The Government put up ACESITA for sale during 1968 but it found no buyer.

(3) After a long delay, the Government created SIDERBRAS in 1973 but it was not only until 1975 that it came to have the role originally envisioned in the GCIS recommendation.

growth rate of 10% per year.[1] Based on these estimates it calculated that if supply was to remain at 90% of 1967 capacity of 4,640,000 tons there would be a deficit of two million tons in 1972 and of 5.7 million in 1977. In order to cover these deficits and to be able to export the equivalent of 900,000 tons of semi-finished products in 1972 and 1.800.000 tons in 1977 (which it considered desireable), capacity would have to be increased from 4.6 million tons/year in 1967 to 8,1 million tons/year in 1972 and to 13.4 million tons/year in 1977 - an increase of 8.8 million tons of capacity in ten years.

After studying the proposed BAHINT expansion plan as well as the plans presented by the individual firms, and comparing them with its demand estimates, it elaborated a National Steel Plan. There were two basic guiding principles behind this plan. The first was to obtain the maximum of productive capacity with the minimum of investment, favoring whenever possible the completion or expansion of existing facilities such as to balance or to specialize

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(1) BAHINT based projection of the demand for rolled propucts through 1975 on a growth rate of 8.5% per year. It also presented an "optimistic" projection based on a 10% per year growth rate, and a conservative projection based on 8% per year. In elaborating its plan, the GCIS adopted the optimistic 10% projection. In the group's opinion it fit the desires and perspectives of the country which included becoming an important steel exporter. In defense of their choice the GCIS pointed out that the difference between the 8.5% "most probable" hypothesis projected by BAHINT and the 10% "optimistic" hypothesis only amounted to 2.7% of the total in 1970 and would give enough time to readjust the projections before 1975 when the differences would be 12%. As it turned out even this optmistic projection fell short of actual growth rates.

production lines rather than the construction of new plants[1].The second was to improve the operating conditions of each plant, trying to give it the maximum efficiency and profitability with respect to its existing and future installations and its specific location. Despite these general guidelines, though, it recommended that it would be advantageous to set up two small size plant (USINOR and COSIMAT) in two periferous regions in order to stimulate regional development, and to set up a new plant oriented for export of

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(1) That the guiding principle was adhered seems to be dramatically shown the case of CSN's expansion plans. CSN presented a plan based on studies done by McKee for expansion from 1.4 million tons to 3.5 million tons during the period 1965-1975 at a total cost of US 558.8 million (1965 prices) to be done in two stages: I (1965-71) for 2,340 thousand tons, and II (1972-75) to reach 3,500 thousand tons. BAHINT found it incompatible with economic conditions of the country given the scarcity of Government resources and dictated that it would be more efficient to have USIMINAS and COSIPA expand because the investment cost per ton of increased capacity would be lower for them since they already had excess capacity in their rolling sectors. BAHINT asked CSN to submit another plan more compatible with the economic situation of the country. CSN submitted an alternative stage I plan to reach 2.5 million tons at a lower investment cost, but BAHINT also found it unacceptable because not only was it incompatible with the market but also, it did not present adequate profitability. BAHINT then elaborated a plan for CSN to increase production to 2.5 million tons suggesting among other things that CSN rennovate rather than purchase a new continuous hot rolling mill which alone would save 43 million dollars. The GCIS however, found that not only was that plan too costly (representing 59% fo its total fixed investment budget), but that it did not yield adequate profitability. Also, investment cost per ton of increase of non-coated flat product capacity was US$ 299 ton, which was almost two times that for an expansion carried out through USIMINAS and COSIPA. As a result the GCIS proposed that CSN divide its plan into two stages, leaving the second for a more opportune moment, and concentrating its production in coated flat products. GCIS recommendation for the first stage was an increase of 250,000 tons and specialization in coated flat products, leaving the non-coated products expansion to COSIPA and USIMINAS.(Plano Siderúrgico Nacional, Síntese, 1969, pp. 83-87.)

semifinished goods with an initial production of 1.5 million tons (Tubarão).

The expansion program recommended by the GCIS(1) was divided into two five year plans. Only the first was carefully worked out since it was expected that changes in economic conditions

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(1) It is interesting to compare the expansion programs prepared by the GCIS for the first five year period with that which had been prepared by BAHINT. The fixed investment required under the two plans was almost identical, but the increase in capacity under the GCIS plan was 3.4 million tons versus 2.2 million tons for BAHINT plan, a relation of 1.54. This made the fixed investment cost per ton of increased capacity US$ 153 under the GCIS program as compared with US$ 238 under the BAHINT sheme. Although the average price per ton of capacity under the GCIS program was only 83% of that under the BAHINT program, because of the different product mix produced under each, the former was more profitable because the capacity increase was 154% of the latter, which more than compensated for the lower average price. One of the main causes for the difference between the two programs was that the GCIS plan relied more on the righting of capacity imbalances with-in the plants. Ths GCIS strategy was to eliminate the large excess rolling capacity in USIMINAS and COSIPA through the expansion of their blast furnace and steel sectors rather than through a simulataneous expansion of all sectors which would be necessary in a plant that was already balanced, as would be the case for the CSN. The GCIS's plan was to increase CSN's capacity only in coated rolled products (a product line in which it was only producer). Besides permiting a lower investment cost per ton of increased capacity, this strategy by encouraging specialization had the advantage of reducing the risk of oversupply and dangerous price competition in non-coated flat products. The savings achieved in this way would finance Tubarão which had a planned production of 1,200,000 tons and which roughly accounted for the capacity difference between the two programs.

might substantially modify detailed plans for the period 1973-1977.

The total cost of the first five year expansion program (1968-72) proposed by the GCIS amounted to US$ 655 million including interest payments and increase in working capital. Fifty six percent were expected to be spent locally. Of the fixed investment total of 556 million, over 81%, was to be spent by the State controlled firms. In terms of the sources of the total funds, the GCIS calculated that only about 20% could come from self-financing on the part of the firms themselves, less than 5% from the private capital market, and 38% from foreign sources (mostly equipments suppliers willing to extend long term credits). This meant that the Government would have to provide the remaining US $ 244 million (38%).

The GCIS suggested that the Government should provide the additional funds directly througt the budget. However, it warned that a system based on such annual budget allocation would not work for more than a year because of the discontinuities which were typical of such processes. Therefore, it suggested that the Government resources should be contributed through an alternate mechanism such as compulsory savings by means of something like an additional tax over the IPI, or through the capitalization of the consumer by offering a 10% reduction in the IPI if he spent a corresponding amount on stock or obrigations of BRASSIDER.

The estimated costs of the second five year plan (1973-77) were of the order of US$ 1,595 million, making the total investment necessary for the decade something in the order of US$ 2,200 million, to increase capacity 8.8 million tons. This would give an average investment cost of US$ 250 per increased ton of capacity. It should be noted that the GCIS did not tackle the problem of how to raise the necessary finance for that second part of the plan which was three times larger that necessary for the the first half. To date, financing the steel expansion remains one of the most crucial problems for the future of the Brazilian steel industry.

5.2. The National Steel Plans And The Greater Role of Government In The Steel Sector.

5.2.1. The 1968-1971 Mini Expansion Plan

At the beginning of 1968, based on the CCIS plan, the Government approved a three year plan 1968-1971. The basic objective of this mini-expansion plan was to establish the planned development of the sector whose expansion was to begin in 1971 by which time it was expected that the steel enterprises would have regained their economic and financial stability after the crisis of the sixties.

The guiding principles of the plan were[1]:

1) The expansion should assure the supply of common products. Imports of special products which could not be economically produced at the small scale demanded by the domestic market were allowed
2) The export of iron ore should be gradually substituted by that of semi-finshed iron or steel products.
3) No help was to be given to any plants whose capacity was below that considered economically justifiable and which required excessive time to achieve such a size.
4) An increase of 1.8 million tons of capacity should be installed by 1970 in order to accompany the previsions of short term internal market demand growth.

The expansion was to begin by the increase in capacity of the plants which presented the most favorable conditions

(1) BANAS, Brazil Industrial 1968/69, pp. 85,88.

(i.e. required smallest investment and yielded the greatest return on the investment). All plants were to be oriented, as much as possible, to specialize in the production of specific groups of products of better quality, higher unit values, and easier placement on the market.

Through the mini-plan capacity was to increase from 3,329,000 tons in 1967 to 5,200,000 tons in 1971 at an estimated cost of US$ 300 million. This was basically the GCIS plan for the state plants.

Specifically, capac ty was to increase 1,871,000 tons broken down as follows: CSN, increase of 250,000 tons; USIMINAS increase of 776,000 tons; COSIPA, increase of 385,000 tons; others increase of 460,000.(1)

The mini expansion plan of 1968-1971 was just a temporary plan while the government prepared its real medium term plan. This plan known as the First National Steel Plan was presented in 1971, and will be discussed in section 5.3.

Thanks to government approved price adjustments by 1968 proper price cost relationship were reestablished. From 1968 on authorized increases in steel prices were above the evolution of the industrial price index. This was immediately reflected in stock market quotations for steel companies and their profitability. As a result, the 1970 annual reports of most companies were very optimistic. Looking specifically at the big three the prospects in 1970 were quite good. CSN's profits were two times those of 1969, COSIPA presented the first positive balance after a long series of deficits, and USIMINAS was finally making a real profit.(2)

(1) Banas, Brasil Industrial, 1969/1970

(2) For the three year period 1968-1970 net profits for the 14 main steel enterprises(CSN,USIMINAS,COSIPA,ACESITA,MANNESMANN, BELGO MINEIRA, INDÚSTRIAS VILLARES, BARBARA, SIDERURGICA RIOGRANDENSE, FERRO BRASILEIRO, AÇO NORTE, and HIME) increased from Cr$ 63.9 million in 1968 to Cr$184.1 million in 1969 and to Cr$429 million in 1970.(Banas, Brasil Industrial, 1972, pp.76-77).It should be noted that 1968 was the first year for which USIMINAS showed a profit(see figure i.1) although it was somewhat artificial given the changes in depreciation methods involved. Taking those into account USIMINAS probably did not really make a profit until 1970.

5.2.2. Fiscal Incentives and Price Structure

As part of the program to help the development of the steel sector the government passed a whole series of incentives. To understand the basic strategy behind these incentives and to get an idea on the price structure and competiveness of Brazilian steel it will be useful to made a quick break to examine this issue.

Since 1969 there were the following series of export incentives: exemption from the IPI tax on industrialized products, credit for the IPI of a certain percentage of the value of export transactions subject to income tax, exemption from special taxes such as Merchant Marine Tax. In general such fiscal incentives for exports were in the order of 35% of the exported value[1].

In 1969 the Government also passed a series of additional general incentives among which were: an increase of the payment period for the IPI and ICM taxes, a three fold increase in credit available for the sector at low interest rates, concession of fiscal credit for intermediate materials used in production, exemption from import duty for 30 months for semi finished products.[2]

In 1971 related to the First National Steel Plan (to be discussed below) the Government enacted two more incentives. First, it prorogated the temporary excemption[2] of import duties and of the IPI and ICM taxes on imports of raw materials, equipment and spare parts for the steel industry. Second it increased the percentage level of the IPI credit for exports from 5% to 10%.

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(1) Banas, Brasil Industrial 1969/1970, p.30

(2) Banas, Brasil Industrial 1972, p.156

(3) Decree Law 569 which had originally been passed in May, 1969.

Figure 5.5 below gives a quick idea of the significance of the import incentives using figures for the period 1971-1973.

Figure 5.5 "IMPORT INCENTIVES FOR STEEL INDUSTRY" (1971-1973)
(millions of current cruzeiros)

Amount of Taxes Excempted	1971	1972	1973
IPI Tax	4	20	36
Import Tax	10	90	181
ICM Tax	17	41	75
TOTAL	31	151	292

Source: CONSIDER, Anual Reports, 1971-1973

Notice the rapid increase in the total exemption from 1971 to 1973 as the expansion of the 1970s got underway. According to BANAS[2], steel projects approved by the National Industrial Development Council between January 1973 and June 1974 (not including those of the large three steel firms) totalled Cr$ 946 million, of which 29% corresponded to fiscal incentives.

(1) BANAS, Brasil Industrial, 1975, p.22

The magnitude of export incentives is difficult to quantity because of changes in the incentives and variations in the impact on different products. However an idea can be obtained by an example taken for the general case of a product in 1971. (Use figure 5.6. to follow the discussion). Taking the price for a ton of steel with-out taxes as a base of 100 the price paid by a domestic customer was 122.8 (including the ICM tax and the IPI tax which are 14.5% and 5.0% respectively of the sales price with ICM). The FOB price paid by a foreign buyer was just 100 because he is not affected by the ICM and IPI taxes. The producer received a tax credit for the ICM and IPI taxes paid on intermediate products. On average these were 2.5% of the sales price(with IPI)for the ICM, and 0.5% of the sales price(with IPI)for the IPI. For domestic sales the producer must turn over to the government the ICM and IPI taxes collected. When the product was exported, on the other hand, the producer received, in addition to the above, an ICM credit and an IPI credit which were calculated as 10% of the sales price. As a result the producer received 103.5 for domestic sales and 123 on export sales. Therefore, a foreign sale at the same price as a domestic sale without taxes gives an 18.8% higher return which in effect implies that he can sell abroad at a correspondingly lower price and still get the same net income.

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(1) This example taken from the study Preços de Produtos Siderúrgicos commissioned by the Ministry of Industry and Commerce and CONSIDER in 1972 and elaborated by the Brazilian firm Tecnometal with the colaboration of all government organs involved in the process.

Figure 5.6

"COMPARISON OF DOMESTIC SALES VERSUS EXPORT SALES"

	Internal Market %	External Market %
A. Sales Price without ICM (85.5 of C)	100.0	100.0
B. ICM (14.5% of item C)	17.0	Exempt
C. Sales Price with ICM	117.0	100.0
D. IPI 5.0% of C	5.8	Exempt
E. Sales Price with IPI (what is paid by custumer)	122.8	100.0
F. Recovery of ICM (2.5% of C)	2.9	2.5
G. Recovery of IPI (.5 % of E)	0.6	0.5
H. Credit of ICM for export	-	10.0
I. Credit of IPI for export	-	10.0
J. ICM Tax paid by producer	17.0	-
K. IPI Tax paid by producer	5.8	-
Net value received by producer	103.5	123.0

Source: MIC/CONSIDER, Preços de Produtos Siderúrgicos, Volume VII, Síntese, Rio de Janeiro Tecnometal, 1972, p.35

This did not include various other export incentives such as: excemption of income tax on the proportion of profits relating to exported products (which could amount to 3% of the sales value); financing for exports (which taking into account the interest difference could signify an additional incentive of 3% on the value of sales; exemption and restitution on fuels and energy sources, etc.

Several studies have been done on the general internal price level and structure of Brazilian products as compared to that foreign countries. The first study covered the period 1962-1971. Figure 5.7. summarizes the historical evolution of weighted prices.

Figure 5.7

COMPARISON OF EVOLUTION OF AVERAGE WEIGHTED STEEL PRICE WITH VARIOUS PRICE INDEXES

(Current cruzeiros Per Ton)

YEAR	Average Weighted Steel Price A	Authorized Increase B	General Price Index C	Wholesale Prece Index D	Average Price / Authorized Increase A/B	Authorized Increase / General Price Index B/C	Authorized Increase / Wholesale Price Index B/D
1962	62	62	62	62	100.0	100.0	100.0
1963	115	111	109	113	103.6	101.8	98.2
1964	192	211	207	208	91.0	101.9	101.4
1965	296	343	325	335	86.3	105.5	102.4
1966	346	388	448	444	89.7	86.6	87.4
1967	435	497	575	558	87.5	86.4	89.1
1968	570	666	714	727	85.6	93.3	91.6
1969	684	765	862	874	89.4	88.7	87.5
1970	925	987	1052	1021	93.7	93.8	96.7
1971	1027	1170	1258	1200	93.8	93.0	97.5

Source: MIC-CONSIDER Preços de Produtos Siderurgicos, Volume VII Sintese (Rio de Janeiro: Tecnometal, 1972) pp.167.

Between 1962 and 1971 the mix of rolled products shifted in favor of those of greater value and within those product groups to those of higher cost and quality. In spite of this the evolution of weighted prices were somewhat below the price increases authorized by the government and significantly below the general and wholesale price indexes. Note that this was particularly ~~true during the 1965-1968 crisis years and that~~ the authorized price levels themselves were below the general and wholesale price indexes.

In 1970 and 1971 the authorized prices were increased faster than the price indexes such that it was possible to partly compensate the previous price compresion suffered by the industry.

In 1971 when the internal price structure of steel products in Brazil was compared to that of various foreign countries(1) it was found that the "nobler" products had a relatively higher price than more common steel products(2). In part this was because the smaller production runs of the "nobler" products increase production costs, but it was also because of a series of extra charges which were traditionally added on to such products.

In general the more common steel products had the same or lower prices than the corresponding products in the internal markets of other countries.(3) Figure 5.8. presents the evolution of the price of steel in Brazil, the U.S.A., and German(4).

(1) USA, England, France, Germany and Japan.

(2) Consistent with this, import duties on the nobler products were relatively higher than those on more common products.

(3) MIC-CONSIDER, Op. Cit., Volume VII, pp. 25-34.

(4) Exchange rates used in the study were based on the June 1961 quotation (which was generally accepted was the proper parity value) adjusted annually by the wholesale price indexes in the respective countries.

Figure 5.8

"COMPARATIVE EVOLUTION OF STEEL PRICE INDEXES 1962-1971"

(indexes: 1967 =100)

YEAR	BRASIL	W. GERMANY	U.S.A
1962	130	106	98
1963	133	106	98
1964	121	105	98
1965	118	105	99
1966	105	106	99
1967	100	100	100
1968	103	102	102
1969	107	109	104
1970	128	111	117
1971	134	117	122

Source: MIC-CONSIDER, Op. Cit., Vol. VII, p.38

Notice that the Brazilian series is U-Shaped with the lowest prices corresponding roughly to the crisis period while W. German and U.S. prices are more or less stable through 1967 after which they show a rise. In 1971 average Brazilian prices were somewhat higher than U.S. and German prices due to the higher relative price of "nobler products" in the product mix.

A recent study compared the pre tax prices of Brazilian products with the internal prices of steel products in the U.S., Japan, W. Germany, France and England for Dec. 1976[1] The comparison, which was based on 12 respresentatives products, showed that: 1) when converted at the official exchange rate Brazilian prices were the lowest in 8 of the 12 products and never among the highest in the remaining four products.[2] 2) When converted at a parity exchange rate based on the July 1961 exchange rate adjusted by the relevant price indexes, Brazilian prices were substantially inferior to internal prices in the U.S., Europe and Japan. 3) Prices in the international market are substantially inferior to internal prices in the exporting countries and have very little to do with real production cost as the international price varies with demand and supply and are heavily subsidized.

In summary the material in this section shows that the general Brazilian policy has been to keep prices as low as possible and close to internal prices in the advanced countries. The reason for this is that steel is a basic imput for the industrialization effort which is being fostered . As will be developed below rather than promoting the steel sector through a high protected price the Government has chosen to help it by direct capital participation in the larger expansion projects and through large subsidies for capital investments which meet its guidelines.

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(1) IBS. Comissão Técnica de Economia, O Preço dos Laminados de Aço no Brasil e no Exterior: Estudo Comparativo (Rio de Janeiro, 1977).

(2) The four products where the Brazilian price was not the lowest were nobler products, showing the persistence of a slightly higher relative price for such products noted earlier.

5.2.3. The Creation of CONSIDER

In 1968 following in part the recommendation of the GCIS report, the Government, through Decree Law 62.403 of March 14, created the Conselho Consultivo da Industria Siderúrgica - CONSIDER- to serve as an advisory council to the Government on iron and steel policy. In its first two years CONSIDER was not very active or powerful as its functions were limited to an advisory role[1]. The five resolutions which it passed during that period dealt mostly with internal organization and laid down some ground rules for the commercialization of steel products from the large three state enterprises.

Decree Law 66 579 of July 19, 1970 restructured CONSIDER[2], making it an agency of the Federal Government presided by the Minister of Industry and Commerce and with the Minister of Finance, Planning, and Mines and Energy as vicepresidents, and changed its status from a consultative organ to a deliberative body with executive powers. Its main objectives were to:[3]

1) Formulate and coordinate national steel policy
2) Fix criteria for the concession of government incentives;
3) Concede priorities to the projects for the creation of new steel mills and to expansion or modernization projects of existing steel enterprises for the purpose of financing by official credit entities.

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(1) The GCIS report has recommended the creation of a Council on Steel Development to formulate steel policy with the responsibility of not just advising but of establishing the basic directives of the planned development of the sector.

(2) CONSIDER was restructured once again through decree nº 74 361 in Dec. 1974, which expanded its scope to non-ferrous metals. It is thus the Council of Non Ferrous Metals and Steel.

(3) BANAS, Brasil Industrial, 1971, p.209

4) Establish the general directive of commercial and financial aspects for the steel enterprises controlled by the State.

5) Authorize the application of accelerated depreciation of priority steel projects in terms of Decree 61.082 of July 22, 1967.

6) By delegation to the Council of Customs Policy concede exemptions of Import Duties for the Capital Goods destined to projects considered prioritary in terms of item 3.

7) Program the investments of the steel sector and coordinate the raising of the necessary public resources (monies).

8) Execute or contract sectoral studies necessary for the planning of the national steel industry.

Technical support for CONSIDER's guidelines and recommendations comes from its executive secretary. That group reviews and evaluates independent reports from the various steel enterprises as they relate to the country's overall industrial development plans. According to Aluisio Marins, CONSIDER's executive secretary, each report is evaluated in terms of technical and engineering plans, market involvement, economic return, financial requirements, etc. Besides the above evaluations, CONSIDER recommends to the CIP (Government Price Control Commission) the prices which shall be charged for steel products, and acts as an adviser on import and custom policies

Every steel enterprise considering any capital improvement or expansion must first submit a detailed plan to ~~CONSIDER for its~~ approval. If CONSIDER approves the plan the company is eligible for a number of financial incentives. These include a full or sliding scale exemption from import taxes(1);other

(1) Once approved by CONSIDER the project is reviewed by the Brazilian Industrial Commision which actually sets the rate of exemption. The purpose of this is to make sure that Brazilian manufacturers have not been excluded, although it seem that a local producer can be excluded if he cannot deliver on schedule

exemption are in terms of industrial products tax and sales tax, a percentage rebate on income tax if the company invests in a development project such as reflorestation or in underdeveloped region such as the Northeast; generous benefits in financing (terms usually includes a 15 year note with interest ranging from 2 to 8% if equipment or materials are purchased from a Brazilian company)[1]

If CONSIDER does not approve the plan the company still has the option of going ahead with its projects, but it will not receive the incentives. This can almost double the cost of the investment.[2]

5.2.4. The Creation of SIDERBRAS

The State's holding company for steel enterprises under state control, which had been recomended by the CGIS' report in 1967 was not created until six years later under the name SIDERBRAS, through Law 5.919[3]. Its objectives were to:

1) Promote and administer the interests of the State activities except in the case of already existing enterprises.
2) Program the necessary State resources for its subsidiaries or associates.
3) Promote the execution of activities related to the steel industry in Brazil and abroad.

Its initial capital was fixed at Cr$ 100 million which were to be integrated by the end of 1974 with State participation of at least 51%.

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(1) Financing is through the BNDE's FINAME(Financiamento de Máquinas e Equipamentos) which finances purchase of all Brazilian equipment for the Brazilian steel industry. Normally the interest rate declines as Brazilian participation increases. If foreign participation is too high the company may be inegible.

(2) 33 Magazine (June, 1976) pp.44

(3) One of its main objectives was to concretize National Steel Policy which called for a large Brazilian participation in the international steel policy.

SIDERBRAS could have been created much earlier. In fact, a project for the creation of such a holding company which would assume stock control of all the steel firms with majority State capital had been elaborated some years earlier. However, the Government gave priority to the expansion programs of its three large firms instead. It also seems that opposition from the BNDE who controlled USIMINAS and COSIPA and which would have had to turn over control to the proposed holding company, was also responsible for the long delay. It should be noted though that whereas the original GCIS recommendation also called for the holding company to be responsible for the coordination, compatibilization and administration of production, sales and investment of the five companies where the State had majority control, SIDERBRAS was to be concerned only with new projects in which the Federal Government was going to participate.

Through Decree Law 6159 of December, 1974 the Government altered the original law, creating SIDERBRAS and gave it stock control over the existing steel enterprises whose voting stock belonged in its majority to the state or to entities of the indirect Federal Administration such as the Bank of Brazil and the BNDE . Such enterprises would become its subsidiaries. The justification was the need to centralize control in order to maximize the results of public investments in the steel sector given that the internal demand was still significantly above national steel production and that the State was responsible for more than 50% of production.

By the end of 1975 six of the seven steel enterprises controlled by the State had been integrated into SIDERBRAS.[1]

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(1) The exception was ACESITA which is still controlled by the Banco do Brasil.

The enterprises and their percentage of national production in 1975 were USIMINAS (21.7%). CSN (18.3%), COSIPA (9.7%), COSIM (2.2%) USIBA (1.3%), COFAVI (1.2%), and PIRATINI (0.9%); giving SIDERBRAS effective control over 55.5% of total Brazilian production. In 1976 SIDERBRAS also acquired majority control of the AÇOMINAS and TUBARÃO steel projects (which were to be built by 1980), and minority participation in the Mendes Junior steel project (which was also to come on stream by 1980).

The shares of SIDERBRAS are held by various direct and indirect agencies of the Federal Government. In 1976 the distribution of shares was as follows National Treasury 84.4%; Caixa Econômica Federal (7.1%), Petrobras (4.7%), Banco do Brasil (1.9%), Companhia Vale do Rio Doce (1.7%), others (0.2%). The total capital was 4,238 billion cruzeiros on December 31, 1976.

To give an idea of the kind of resources, SIDERBRAS controls it may be noted that during fiscal year 1976 it obtained funds totalling Cr$ 3.126 billion (capital increase of Cr$ 1.489 billion, increase in long term debt of Cr$ 1.571 billions and Cr$ 66 millions from operations). Of these Cr$ 3.090 billions were invested in its subsidiaries and associated companies, Cr$ 25 millions in fixed assets and Cr$ 11 millions in other items including studies related to the Master Steel Plan.

(1) 73% of this was invested in the big three Companies.

5.2.5. The First National Steel Plan (1971)

According to the four ministers who presented the plan in 1971, the steel industry had overcome the financial difficulties which had been compromising its growth and was prepared to fullfill its role in development under the guidance of CONSIDER which had recently been reorganized and presented with the instruments necessary for that purpose. In 1970 steel production had been 5.37M.t.a. while consumption had been 5.80 M.t.a. Steel plants were operating at capacity whereas consumption was increasing at 500.000 tons per anumn. As the Government felt that it would be convenient to export at least 10% of production in order to earn some foreign exchange and to maintain a foothold in the foreign market, a deficit of about one million tons was expected in 1971. This would have to be covered through imports. Following the Presidents's goal of creating a steel industry with 20 M.t.a. installed capacity by 1980 in order to completely supply the national market and have the necessary reserve capacity to fill demand peaks, the plan called for an increase in installed capacity at a rate of 12% per year. This would involve investments of approximately Cr$ 15 billion through 1980 at 1970 prices. The expansion would permit an increase in per capita consumption from 63 kilograms in 1970 to 125-30 in 1980. During the period when demand was greater than supply, the deficit would be covered by imports. CONSIDER was to import all the products which were to be further elaborated by the state firms.

Increase in the capacity of the flat sector was given priority by CONSIDER. The capacity increase was to be fullfilled by the expansion of the big three state companies. The plan included a new blast furnace for each of the three to bring capacity in 1980 to 4 M.t.a. for CSN., 3.5 M.t.a. for USIMINAS and 3.4 M.t.a. for COSIPA adding up to a total capacity of almost 11 M.t.a. During the first five years of the plan capacity was to increase 100%. The budget for this period was Cr$ 2,050 million for CSN, Cr$1,500 million for USIMINAS, and Cr$ 1,950 million for COSIPA, representing altogether almost one-third of the total budget (investment, financial costs, and increase in working capital) planned for the whole decade. USIMINAS and COSIPA, which had suffered adverse effects from their large initial investments in relation to production, were to regain financial health through a consolidation and rescheduling of their debts in order to establish adequate relationship in their composition. Furthermore, begining in 1971 all steel enterprises of mixed economy were to present consolidated balance sheets and adopt standard costs according to studies being realized under CONSIDER's coordination.

In the non-flat sector, production was to be increased through the expansion of existing enterprises and the creation of new ones through projects that presented "solid technological and financial bases" presumably as determined by CONSIDER. This sector was to continue under private initiative although it would receive Government support through credit stimuli for the execution of expansion plans and the creation of new plants. The plan also provided that the Government might participate as a minority shareholder in order to viabilize projects requiring such major investments that the private sector could not handle by itself. CONSIDER studies indicated the necessity of having capacity of common non-flats be 4,650,000 tons of ingots by 1975. That represented an increase of 2,5 million tons over current capacity. By 1980 capacity was to reach 8 million tons of ingots. The special steel sector was supposed to expand capacity 60% by 1975 when it was to reach almost one million tons. At the time plan was announced projects were already under way for the production of stainless steel whose demand was increasing rapidly due to the expansion of the chemical and petrochemical industries.

The 1971 Steel Plan also specified that CIP(1) resolution nº 19, which assured adequate profitability for the steel industry through price cost margins which were compatible with increased investments required by the large expansion plans, was to be maintained as a guideline in setting steel prices. Additional financing for the plan was to be done primarily through the BNDE which was to be given appropriate budgets by the Union and the National Monetary Council to fullfill that purpose.

Long term planning was to be based on a market and technical studies. The first of these which was already under way under auspices of the IBS, was to become known as the MBA-1 (Mercado Brasileiro de Aço-1);it shall be discussed below. Such studies were to be updated annually and were to provide the basic imput in defining the specific rolling capacity to be installed in the expansion plans.(2)

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(1) CIP is the Conselho Interministerial de Preços, the Government agency in charge of setting prices.

(2) As can be seen from the preceding summary of the plan, in this first stage the main objectives of the Government were to put its steel companies at adequate levels of costs and production, consolidating their expansion plans before undertaking new investment projects of its own: and to begin to lay down guidelines and incentive schemes to control the development of the private sector.

5.2.6. Market Demand Estimates and Planning

To conclude this brief survey on the increasing role of the state in the steel a quick sumary of the various market demand studies and expansion plans is in order.

There have been five market studies since launching the First National Steel Plan in 1971, and a final Master Steel Plan which was to be completed by 1977 is still in the works. The projections of all five plans as well as those of the earlier BAHINT and CGIS studies are presented in figure 5.9. Notice that the BAHINT, CGIS and MBA I [1] plans all underestimated actual consumption levels. On the other hand, the MBA II and MBA III studies (announced in 1972 and 1975 respectively) over-estimated demand and it was not until the RAM-I (1976) and RAM-II (1977) studies that the estimates were reduced to more realistic levels.

The change between the MBA-I and MBA-II/MBA-III studies had a marked impact on expansion policy. Because higher than expected growth in steel consumption between 1970 and the beginning of 1972 made the results of the MBA-I study obsolete, CONSIDER commissioned MBA-II in 1972.

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(1) The MBA-I plan was the first commissioned by CONSIDER and it was the basis for the First National Steel Plan launched in 1971. It was massive study which involved the elaboration of a matrix of steel products and steel consuming sectors for the year 1969 and its projection through 1980 using both historical series and surveys of future consumption estimates by the 130 principal steel consumers.

Figure 5.9

"STUDIES PROJECTING BRAZILIAN CONSUMPTION OF ROLLED PRODUCTS" (1)

(millions of tons)

Products / Years \ Name / Date	BAHINT 8/66	GCIS 12/67	MBA I 4/71	MBA II 12/72	MBA III 1/75	RAM I 2/76	RAM II 7/77	ACTUAL
Flat Products								
1966	1.269	-	-	-	-	-	-	1.494
1970	1.795	1.843	-	-	-	-	-	2.114
1975	2.696	3.099	3.561	4.287	5.085	-	-	4.355
1977	-	3.693	4.325	5.354	7.111	5.661	-	5.083
1980	-	-	5.788	7.454	10.328	7.904	7.083	-
1985		-	-	-	18.785	15.355	13.001	-
Non-Flat Products								
1966	1.383	-	-	-	-	-	-	1.510
1970	2.006	2.087	-	-	-	-	-	2.137
1975	2.899	3.251	3.548	3.992	4.357	-	-	4.206
1977	-	3.947	4.276	5.050	5.725	5.164	-	4.416
1980	-	-	5.658	7.210	8.201	7.052	6.292	-
1985	-	-	-	-	14.674	13.814	10.844	-
Total Rolled Products								
1966	2.652	-	-	-	-	-	-	3.004
1970	3.801	3.930	-	-	-	-	-	4.251
1975	5.591	6.350	7.109	8.279	9.442	-	-	8.561
1977	-	7.640	8.601	10.404	12.836	10.825	-	9.499
1980	-	-	11.446	14.664	18.529	14.956	13.375	-
1985	-	-	-	-	33.459	29.169	23.845	-

Sources: Studies cited
Actual consumption from MBA nº 2 and RAM studies

(1) Taken from IBS Comissão Técnica de Economia "A Industria Siderúrgica Brasileira Face a Conjuntura Mundial do Aço" (8th. Annual Brasilian Steel Congres: Rio de Janeiro, April 4, 1978)

The revised estimates of the MBA-II implied that if Brazil wanted to supply its internal market needs as well as to export 20% of its production it would have to expand to more than the 20 M.t.a. capacity originally set as the goal for 1980 in the 1971 Steel Plan. As a result, in 1973 the President of Brazil anticipated the completion date for the fase III expansion of CSN, COSIPA and USIMINAS from 1980 to 1978. This fase III expansion program provided that these three state enterprises increase capacity to nearly 11 m.t.a. The new plan was to produce 20 m.t.a. in 1978 and 25-27 m.t.a. in 1980.(1) In some circles it was even expected that installed capacity would reach 32 M.t.a. in 1980 and official enthusiasm reached the point of announcing that by 1977 Brazil would become a net steel exporter.

It was widely quoted in both offical media and domestic press that there was a steel shortage in the world market. Estimates were that the world would have to increase installed capacity by 300 M.t.a.by 1980 which represented a more than 50% increase. Nevertheless, some specialists shrewdly pointed out that such perspectives of shortage were due to the increased commercialization in steel which was caused by speculative forces, not real increases in demand.

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(1) In 1973 three large Government sponsored projects for export oriented plansts were being negotiated. The Usina de Tubarão (in Espírito Santo), whose conception dated back to the BAHINT and GCIS reports, had already passed the prefeasibility stage and was already constitued as a pilot plant. Its basic project was to be elaborated starting in March, 1974. Stock was to be distributed as follows: SIDERBRAS, 51%, Kawasaki (Japan) 24.5%; FINSIDER(Italy) 24.5%. The initial stage was for a capacity of 3 M.t.a. of semifinshed products at an investment cost of Cr$ 5.2 billion. It was to begin operation with that capacity in 1977 and to expand to 6 m.t.a through a second stage to be completed by 1980. The usina de Itaqui was a project to use iron ore extracted from the newly discovered Carajas deposits (in the state of Maranhão). It was at the stage of signing preliminary agreements between Nippon Steel (Japan) and SIDERBRAS. Fifty one percent of the capital to be held by

The oil crisis which had a different effect in the short and medium runs, significantly affected the estimates and the planning. In the short run, as a result of the crisis there was an immediate run in demand for steel products which lead to a substantial increase in prices as can be seen in figure 5.10 below.

In Brazil apparent consumption of rolled products in 1973 increased 19.1% over the previous year. In 1974 it increased 27.7% more. Such a rapid increase in consumption led to an increase in imports. Whereas imports as a percentage of apparent consumption had averaged less than 11% for the preceeding 10 years, this ratio jumped to 22% in 1973 and to 43% in 1974. The bulk of the increase in demand was in flat products where apparent consumption increased 46.6% in 1974, making flat product imports account for 60% of domestic flat product consumption whereas the average for the previous 10 years period had been less than 15%. (See figure 5.2)

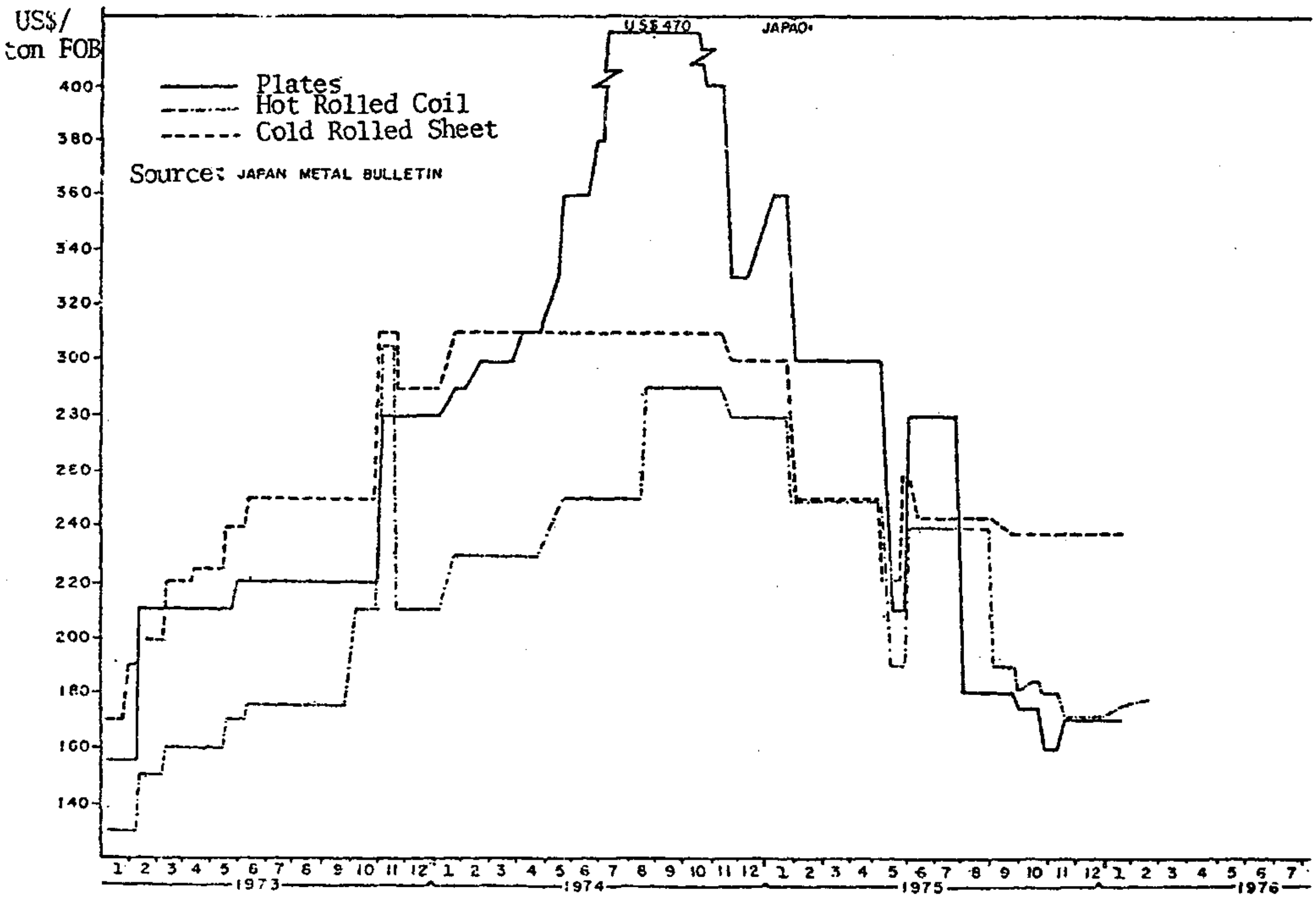
Footnote 2 continued from the previous page.

SIDERBRAS, the rest by foreign groups led by Nippon Steel. The first stage was to be 4 m.t.a. of semi-finished products to come on the market in 1980 at a total investment costs of Cr$ 6 billion. The final size was to be 16 m.t.a. after passing through an intermediate stage of 12 m.t.a. The third project was a hot strip rolling mill in Espírito Santo to finish billets supplied by the Tubarão plant. Pre-feasibility studies has been completed by CONSIDER and Klockner during 1973. Its first stage was to give it a rolling capacity 1.5 m.t.a by 1977. A second stage would increase that to 3 m.t.a. in 1980. Total cost through 1980 was forseen at Cr$ 1.416 billion. SIDERBRAS was to hold 50% of the shares, Klockner 40% and Tubarão the remaing 9%. In 1973 CONSIDER also approved the creation of private integrated steel mill in Juiz de Fora (Minas Gerais), by the Mendes Júnior group. The cost of the first stage (1.2 m.t.a) to be completed by 1978 was estimated at Cr$ 4.3 billion. It was to reach 2 m.t.a in 1980 and a final capacity was to be 4.5 m.t.a. Capital was to be controlled by Mendes Júnior with the participation of SIDERBRAS, the Government of Minas Gerais, the Prefeitura of Juiz de Fora, he BNDE, Nippon Steel, and the Mitsubishi Co., (Banas, Brasil Industrial 1975, pp.22)

Figure 5.10

"EVOLUTION OF INTERNATIONAL PRICES OF STEEL PRODUCTS"

1973-1976



Source. CONSIDER, Relatorio Annual 1975, p.9

Production of steel ingots which had been growing at an average rate of slightly over 12% since the end of the Brazilian steel crisis in 1968 only increased 4.9% in 1974. This was the lowest recorded since the steel crisis of the mid sixties. Production of flat rolled products actually fell 6.9% that year[1] which helps to explain, in part, why imports of flat products increased so dramatically.

The MBA-III projections which were completed in 1974 (see figure 5.9.) showed that if only fase II was completed for the large three steel companies, there would be a deficit of 2.1 M.t.a. in 1977 which would increase to 8.6 in 1980. (Notice that the MBA-III demand projection for 1980 was 2.8 m.t.a. greater than MBA-II's)

Figure 5.11.

INSTALLED CAPACITY AND DEMAND PROJECTIONS (MBA-3)
(million tons of steel in ingot equivalents)

YEAR	FLATS	NON FLATS	TOTAL	MBA-3 PROJECTIONS	DEFICIT	MBA-2 PROJECTIONS
1975	4.0	5.3	9.3	10.7	-1.4	11.1
1977	7.2 (1)	6.6 (2)	13.8	16.1	-2.1	
1980	7.2 (1)	6.6 (2)	13.8	22.4	-8.6	19.6
1980	11.6 (3)	8.5 (4)	20.1	22.4	-2.6	

NOTES: (1) With completion of Phase II (CSN: 2.5 m.t.a., USIMINAS: 2.4 m.t.a. COSIPA: 2.3 m.t.a.) which would require U.S.$ 1.7 billion in addition to U.S.$ 772 million already applied.

(2) The non-flat sector presented investment plans totalling U.S.$ 83.8 million during 1974 and U.S.$817 million during 1975. This would increase capacity 1.3 m.t.a. by 1977.

(3) With acceleration of Phase III (CSN: 4.5 m.t.a., USIMINAS: 3.5 m.t.a COSIPA: 3.5 m.t.a.) which was estimated to cost U.S.$ 3.2 billion

(4) Non-flat capacity estimated to increase 1.9 m.t.a. with additional investment of U.S.$ 1.3 billion.

Source: Banas, Brasil Industrial 1975/6, pp.38

[1] Production fell because the energy crisis led to a coal shortage which severaly affected the coke based flat product producers like USIMINAS. Notice however that overall production increased thanks to an increase from the non-flat sector which is not dependent on coal. (figure 5.1)

In order to reduce those deficits, in late 1974 Consider approved the Phase III expansion plan for the three flat product producers which would increase their capacity to 11.6 million tons per annum by 1978[1]. Non-flat productive capacity was estimated to increase 1.9 million tons per annum with additional investments of U.S.$ 1,333 million. In mid 1974, the steel plan then under elaboration foresaw production of 20-25 M.t. of steel in 1978 and an installed capacity of 32 M.t. in 1980, the last year for which fixed goals were set.[2]

In 1975 total world production fell 8% from the 1974 peak of 710 M.t.a.However, even with that reduction in production prices, which had increased in the order of 200-300% as the immediate result of the crisis, started a downturn in late 1975 and fell throught 1975. By the end of 1975 they were almost back to pre-1973 levels. The steel industry thus reflected the worldwide economic recession. This has led many large producers to shut down complete plants or part of large plants. As a result some of the foreign partners for the big Brazilian expansion projects have had second thoughts about investing in such export oriented plants and have withdrawn. This was the case of U.S. Steel, British Steel, Nippon Steel and Usinor in the case of the Itaqui project,

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(1) Banas, Brasil Industrial 1975, p.124

(2) The II National Development Plan (II PND) covering the period 1975-1980 which was launched. in September 1974, foresaw steel ingot production at 22.3 M.t.a in 1979 based on projects known by June 30,1974.

and that of Kobe Steel in the case of rolling project for Tubarão.(1)

The year 1975, therefore caused a detour in the plans. GNP growth was only 4.3% . While steel ingot production and rolled steel production grew at 10.7% and 10.8% respectively, apparent consumption of steel products actually decreased slightly over 6%(2). Imports of rolled products fell 42%. This downturn led

(1) These included the Sepetiba project in Rio de Janeiro(production capacity of 10 M.t.a. by stages); the Itaqui project in São Luiz de Maranhão (Production capacity of 12 M.t.a; and the rolling mill in Espírito Santo for Tubarão (1.5 M.t.a. of rolling capacity).
It seems that as a result SIDERBRAS decided to concentrate its efforts on the Tubarão project in Vitoria (Espírito Santo) and to freeze the other large projects. Apparently the Government established a Cr$ 20 billion limit for investment in steel bout 70% of these are earmarked for the third phase expansion of the large three state firms which is to raise their capacity to 11.6 M.t.a. Of the remaining 30%, Cr$ 2.2 billion are for Tubarão (although its original budget had been set at Cr$ 3.3 billion) and Cr$ 3 billion are for Açominas. The remaining .6 billion cruzeiros are to be spent on smaller enterprises. In effect, SIDERBRAS cut back Cr$ 15 billion in investments by deciding to reduce the future steel ingot capacity of COSIPA from 3.4 M.t.a. to 2.4 M.t.a. and that of USIMINAS from 4.6 M.t.a. to 4.1 but maintaining their rolling capacity. Under the new scheme the 1.5 M.t.a. difference would be supplied by ingots from Tubarão. Thus, Tubarão has been changed from the purely export oriented project that was originally presented, to a 50/50 mix of exports and production for the national market. This mix roughly reflects the composition of capital SIDERBRAS 51%, FINSIDER (Italy) and Kawasaki (Japan) 24% each.

(2) The following table serves to illustrate at least shematically the downturn in economic activity which occurred in 1975 as compared to previous years.

PERCENTAGE RATES OF GROWTH

	1973	1974	1975
GNP growth	11.4	9.6	4.3
Industry growth	15.0	8.2	4.2
Construction Industry	15.2	7.8	3.8

Source: CONSIDER ANNUAL REPORTS 1973-1975

Consider IBS-SIDERBRÁS to restudy the 1974 projections and submit a 10 year plan called the Master Steel Plan.(1)

This is supposed to be a comprehensive plan involving 18 major studies with the participation of CONSIDER, SIDERBRAS and the Secretariat of Industrial Technology of the Ministry of Industry and Commerce.(2) The plan was to go through three consolidations stages yielding a final report in 1977. Unfortunately at the time of this writing (August, 1978) the definitive plans has not been announced.

The delay seems to be related in part to the uncertainty resulting from the prolonged effects of the world recession. Through out the 1975-1978 period there have been various different reports of the goals of the plan.(3)

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(1)However in mid 1975 CONSIDER was still talking in terms a minimum production of 46.5 m.t.a. in 1985. See MIC/STI, Indústria de Bens de Capital, São Paulo, Setembro 1975, p.499

(2)Besides a general planning document to be called "The Steel Industry in the Context of the Global Planning of the Brazilian Economy :Definition, Directives and Planning" there are to be studies on: the market, production, prices, raw materials, transportation, energy, production structure, research and technology, engineering, ecology, equipment manufacture, legislation, human resources, a data bank, related industries, economic-financial analisis, and expansion of the steel industry until the year 2000.

(3)Banas, Brasil Industrial 1975(p.121) for example claims that the 1975-1985 plan hopes to guarantee Brazil an installed capacity of 40 m.t.a. of steel products by 1975. The plan is supposed to be based on a strategy of self suficiency (demand estimated at 20 m.t.a. in 1980) plus a significant role in exports which are supposed to amount to 9 m.t.a. in 1980. Even as late as 1977,an article by Sidonio Cardoso Naves, the representative of the Secretary of Planning of the Presidency of the Republic to CONSIDER discussed the Master Steel Plan in terms of producing 60 M.t.a by 1987/1988. See Planejamento e Desenvolvimento Ano 5, Número 50 (Julho 1977) pp. 14-19.

The latest news, however, is that the goal for production in 1980 has been reduced to something in the order of 15 M.t.a., more consistent with the revised demand estimates of the RAM-I and RAM-II studies.

The main difficulty has been and continues to be financing such expansion projects. The plan of the previous government of building capacity up to 32 million tons by 1980 was taken during the euphoria of 1973. It demanded more than 20 billion dollars of investment which was much more than the country could handle without giving up other major investments.

During the trienium 1971/1973 investments in the steel sector averaged US$ 300 million per year. In the trienium 1974/1976 they averaged US$ 1 billion. In 1977 investments were close to US$ 1.5 billion. For the period 1978/1981 are estimated at annual averages above US$ 3.5 billion[(1)(2)]

With the withdrawal of foreign capital the steel industry turned to the Government for greater help in financing *through the creation of some type of automatic mechanism to tap* financial resources. In April 1977, through Decree Law 1542, the Government gave steel enterprises a new fiscal incentive for expansion plans. It gives steel enterprises the right to use for investments in expansions and modernization programs 95% of the IPI tax they would have had to pay as long as such expansions and modernizations receive approval by CONSIDER. It affects operations which take place between May 1,1977 and Dec. 31.1986. In 1977 this incentive generated Cr$ 1.4 billion. It is estimated to generate Cr$ 3.3 - 3.5 billion in 1978[(2)]

(1) Speech of Minister of Planning Reis Velloso at the 8th Brasilian Steel Congress, Rio de Janeiro, April, 1978.

(2) This would represent 8% of Brazilian yearly gross capital investment.

(2) IBID.

At the moment all the large plans are behind schedule, except for USIMINAS. The latest estimates are that CSN and COSIPA, will not complete their Phase III expansions plans until 1980.(1) Tubarão (3 M.t.a) and Mendes Junior(2) will only enter into production in 1981 or 1982. Finally Açominas(3) (2 M.t.a) which was finally made possible by the injection of State money, will only start production in 1981.

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(1) According to an article in Tendencia (III nº 33 June 1976, p.38) the flat steel producers will only reach a capacity of 8.8 M.t.a in 1980 rather than the originally planned 11.6 M.t.a in 1978. However, as the revised demand is only 7.9 M.t.a. Brazil should achieve self-suficiency in this sector. In non-flats revised demand is 7.9 M.t.a. and self suficiency will also be guaranteed through Mendes Júnior and Açominas.

(2) Although initially planned as a small private plant, Mendes Junior ended up receiving substantial state participation because the State forced the plan to be much larger than was planned by the private group, but the latest news is that it will finally to produce only 600,000 tons as originally planned.

(3) Açominas received one billion cruzeiros in government funds. This raised crises of protest from the private sector because not only did it mean a change in the rules of the game (i.e. State entering the non-flat sector which had been reserved for private initiative) but it also meant competition for Mendes Junior. The private sector wants the State to define its degree of statitization in the steel industry and to define the scheme for the allocation of funds for the sector.

5.3. The Development And Strategy of USIMINAS In the Macro and Market Context.

5.3.1. Start of Production And Emphasis On Exports

USIMINAS was planned for the production of thick plates for the naval industry (which were not currently produced in the internal market), cold rolled sheets for the automobile industry (which was in a stage of constant expansiom); sheets (for large liquid reservoirs needed by PETROBRAS, the government owned oil company); and storage silos (for agricultural products).

The original equipment of the plant conisted of:

2 coke oven batteries of 50 ovens each
1 Dwight Lloyd type sintering machine
2 blast furnaces
1 steel shop with 2 LD converters of 50 tons each
1 reversible slabbing mill
1 Plate mill (1)
1 Hot strip mill
1 Cold strip mill

The start of production was done in two stages. In the first stage which was finished in 1963 only plate was produced until 1965 when the hot and cold strip mills were finished. (2)

The company produced its first rolled products in 1963. Its thick plates received approval from Lloyds register of London which permitted USIMINAS to start supplying the naval industry

(1) The plate mill could be used either for the production of plate or for descaling and reducing the thickness of slabs to be used in the hot strip mill. Switching from one use to the other involved a stop in production for readjustments.

(2) This was part of the original plan. Until its finishing facilities were completed USIMINAS was to supply part of its semifinished products to COSIPA and Ferro and Aço of Vitoria which had greater capacity installed for finishing than for producing steel.

Figure 5.12

EXPORTS OF USIMINAS 1963-1972

EXPORTS	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	TOTAL EXPORTS	1963-1972 Total Value US$ 1,000
TOTAL	48	126 743	109,136	87,450	182,355	150,751	124,252	97,000	50,288	92.094	1,067,445	106,523
LAFTA		34 497	103,274	41,606	82,801	71,208	na	na	36,881	18,890	592,284	65,252
Argentina		33,996	103,204	38,958	77,467	65,715	na	na	30,993	15,399	537,641	57,865
Bolívia		-	-	-	-	-	na	na	-	-	75	12
Colombia		-	-		-	-	na	na		-	5,118	694
Paraguay		-	-		-	-	na	na	1,395		2,261	546
Uruguay		,501	70	2,648	3,936	4,542	na	na	4,519	3,491	36,347	4,507
Venezuela		-			1.398	951	na	na			10,842	1,608
Argélia		-	-		-	-	na	na			1,873	286
Belgium		-	-	-	-	-	na	na			4,580	574
Japan		40,863	-	39	21,291	-	na	na	-		109,187	6,016
Puerto Rico		-	-	-	-	-	na	na	-	1,793	2,801	383
U.S.A.		51,383	5,862	45,805	78,263	79,543	na	na	13,407	71,411	356,720	34,012

Source: USIMINAS Annual Reports 1968-1973 and PETROBRAS. In 1964 its equipment and plates received approval by the "Veritas" Bureau of Brussels. In 1964 when the first signs of weakness were already evident in the internal market USIMINAS started exporting thick plates to Argentina, the U.S., Uruguay and Japan, immediately making it the record holder for export of Brazilian flat products, a position it still holds today.

In large part this seems to have been possible because of the quality of its products. From the beginning USIMINAS put an emphasis on quality. The philosophy adopted was that since it could not start out the biggest given CSN's existence, it would try to be the best. As early as 1964 technical studies were undertaken to improve the quality of its thick plates. In 1964 already 49% of its production was structural sheet for the naval and boiler industries, 27% was general structural sheet and only 24% was for general use.(1) (USIMINAS' policy of greater product diversification and quality improvement will be covered in more detail in chapter seven.)

During 1965 the firm concluded the stage destined to give it a capacity of 500,000 tons per annum with the entrance into operation of its hot and cold strip mills and second blast furnace. As was noted, 1965 was right in the middle of the steel crisis affecting the whole industry.

Because of the weakness of the domestic market(1) the company placed a greater emphasis on exports. This can be seen in figure 5.12. which shows its exports for the period 1963-1972. Notice that exports were greatest precisely during the years marking the steel crisis (1964-1968). The peak was in 1967. That year

(1) USIMINAS; Relatório Anual 1964, p.7

(2) In 1965, for the first time in the history of the Brazilian steel market, production of rolled products was greater than apparent consumption (see figures 3. and 6.1) This was most marked in the flat products sector.

Brazilian production of flat rolled products fell only 4.2% while apparent consumption fell 18.5% so it was necessary to export the excess. Because of the size limitation of the LAFTA market USIMINAS actively studied the U.S. market and in spite of disadvantages in transport costs was able to increase its sales to the U.S. 71% with respect to 1966, thanks to the quality of its products.[1]

5.3.2. Internal Financial Difficulties And Proposed Expansion Plans

At the same time that the steel market in general was in crisis, USIMINAS was undergoing a several internal financial crisis because its actual construction costs had turned out to be much greater than planned due to rapid inflation, large

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(1) Exports in 1971 were considerably reduced due to increased demands by the internal market. The 1963-1971 anual average was 103 thousand; in 1971 exports were just 50 thousand. The average price per exported ton was 38% greater in 1971 than the average for the whole period, due to an increase in the percentage of finished products exported. In 1972 exports increased again particularly to the U.S., but they had to be reduced to a total of 48 thousand in 1973 due to a sharp increase in domestic demand which led the Government to regulate exports, In 1974-1975 Brazilian imports of flat products were 32% and 60% respectively of apparent consumption as a result of speculative demand resulting from fear of the energy crisis. (see figure 5.1 and 5.2) State controlled companies such as USIMINAS became net importers under a program whereby they were allowed to import in order to provide an orderly supply to the tumultead internal market. In 1974 -1975, and 1976 USIMINAS imported 198,000, 269,000 tons and 158,000 tons respectively.

currency devaluations, and some alterations in the original projects.[1] In 1965 it was already obvious that firm would reach the break even point only when it attained a minimum production level of one million tons per annum[2].

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(1) The original budget elaborated in 1957 had calculated the total cost of the plant at Cr$ 12.3 billion which was to be financed: 4 billion capital stock, 2.95 billion from the BNDE and 5.358 billion from foreign credits. By June 1961 the costs were being reestimated at Cr$ 43 billion. By the beginning of 1962 the estimates were for a total cost of Cr$ 80 billions and stockholders agreed to increase the capital stock to Cr$ 18 billion with the Japanese maintaining their share at 40%. The firm obtained substantial advances from the BNDE, Nippon USIMINAS, the National Treasury, and the Banco do Brasil. By the end of 1962, however it was again obvious that the estimates were below actual costs due to a high inflationaly increase in materiaç and labor costs and a further depreciation of the exchange rate. After lengthy negotiations between the Brazilian and Japanese partners, which went from July 1964 to the end of January 1965, agreement was reached on increasing the capital stock to Cr$ 150 billion, this time the Japanese did not increase their share in proportion to the capital increase so their participation fell to 21.5% and it never increased above that again. However, the Japanese debt due in 1964 and 1965 and 70% of the European debt due in 1965 were rescheduled for payments starting in 1968. (Information taken from Company Annual Reports 1957-1965)

(2) USIMINAS, Relatório Anual 1965, p.16; Relatório Annual 1966, p.40. In fact, according to the latter it was recomended that production be increased to two M.t.a.

An expansion plan to attain one M.t.a. capacity was drawn up in 1965. It was estimated that investments of close to 70 million dollars would be necessary to implement it. The plan was submitted to an international financial agency which did not approve it. In 1966 a complete study for the one M.t.a plan and a preliminary study for an expansion to two M.t.a. were completed. Both were submitted to the BNDE - Booz Allen Hamilton group.[1] However, they were not approved. In 1967, the GCIS report suggested that USIMINAS increase its capacity to 1.4 M.t.a. USIMINAS' Technical Department immediately prepared the 1.4 M.t.a.[2] expansion plan suggested by the GCIS. This plan was approved in the 1968 National Steel Plan a launched by the President of Brazil[3]. The plan foresaw the installation of a new coke plant, new sinter plant, a remodeling of the blast furnaces, installation of a 3rd BOF convertor, a new continous cold tandem mill, and various complementary oven installations.[4]

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(1) USIMINAS, Relatório Anual 1966, p.40

(2) USIMINAS, Relatório Anual 1967, p.17

(3) The 780.000 tons increase approved for USIMINAS represented 55% of the expansions authorized for the 3 large steel producers.

(4) USIMINAS, Relatório Anual 1968, p.18. The basic engineering for this plan was prepared by a joint Brazilian-Japanese Team. The Japanese team was sent by the Yawata Iron and Steel Co. to Brazil to gather the necessary preliminary information. Subsequently a Brazilian team travelled to Japan to work on the studies which were actually being developed in that country.

There were considerable delays in the implementation of the 1.4 M.t.a expansion plan. In large part they were due to various difficulties in arranging the financial scheme for the plan.(1) It was not until the second semester of 1970 that the first parts of the new equipment entered into operation.

In March 1970 the Ministry of Industry and Commerce asked USIMINAS to present a 3 year expansion plan to cover the period until 1973. USIMINAS used the invitation to present a 10 year expansion plan to cover the period 1970/1980.(2) Its justifications were that such a plan would make possible an analisis of the expansion to 1.4 M.t.a. then in progress in relationship to future expansions of the company and permit a broader vision of the possible contribution of the firm's own internal resources for an expansion to 3.5 M.t.a. by 1980. The 10 year plan suggested

(1) Most of the imported equipment for the plan was financed through a tied loan with the Japanese. There were some difficulties in obtaing Brazilian Government approval for the financing scheme as well as additional financing from the BNDE because of the very high debt sales ratio of the company and the fact that US$ 75 million owed to foreigners would be due within the period 1969-1974. This problem, which also seems to have been the reason why previous expansion plans had not received approval, was finally solved when the National Treasury agreed to absorb a major portion of these obligations in exchange for shares in the company as it had done some years before for CSN and COSIPA. It was not until late 1969 that the BNDE decided to extent USIMINAS the cruzeiro credit or guarantee the company's loan from the Japanese. The evolution of the companies debt/sales ratio between 1966 and 1971 is given below:

1966	1967	1968	1969	1970	1971
5.23	3.53	3.48	2.66	2.01	1.00

(Figures taken from company annual reports)

(2) USIMINAS, Plano Decenal (Maio, 1970)

that because of the delays which had occurred in the execution of the 1.4 M.t.a. plan and that because of imbalances which had resulted between the programmed capacity of the metal producing sections and the rolling section it was advisable to reformulate the plan to 1.8 M.t.a in order to maximize the utilization of the investments.(1) It proposed that instead of reforming the second blast furnace as originally planned, a third, new generation blast furnace, with a useful internal volume of 2.500 m^3 should be installed. It would not only fullfill the needs of the 10 year expansion plan, but also satisfy the modern scale conception of such productive units. It would also eliminate the shortage of pig iron that would be caused by the stop of blast furnace nº 2 for reform in 1973 which would adversely affect the production plan and create a need to import US$ 22 million worth of products. This stage was to be concluded toward the end of 1973. A second expansion to produce 2.4 M.t.a. would be executed between 1974 and the end of 1978. The main objective to be achieved was righting the result defficiency in rolling of thick plates which resulted from the expansion of metal producing capacity and which was coherent with provisions of shortage for that product. To that end a new plate mill was to be installed. The necessary increase in steel capacity was to be met by a substitution of the three BOF convertors by some of greater size. A third expansion to reach 3.5 M.t.a was to be executed between 1977 and 1980 to meet market needs forseen for 1981-1985. It would utilize to the limit the pig iron producing capacity of the three blast furnaces and would require a new steel shop with continous casting equipment to supplement the plant's slabbing capacity. In the rolling section to capacity of the cold rolling mill would be doubled through a remotorization to

(1) The poor financial performance of the company described in p. stemmed in part from high investment to the actual capacity of the plant. The dramatic improvement which were achieved in the ratio of capital output value was shown in figure 1.1.

increase its speed.

This expansion plan was approved by CONSIDER [(1)] and the BNDE[(2)] which qualified USIMINAS to receive the various fiscal incentives which subsidize capital investment explained before. Due to an overlap between the 1.4 M.t.a. expansion in course and the intermediate 2.4 M.t.a. plan, they were consolidated both technically and financially into one which was to be finished by December of 1973.

5.3.3. USIMINAS' Actual Production And Expansions

USIMINAS has in fact gone through with the 10 year plan. In order to help orient the analysis of technical change which will developed in the next chapter Figure 5.13 presents a flow diagram of what the initial integrated plant looked like in 1966 and figure 5.14 presents a flow diagram of what the plant will look like by next year when it completes its expansion to 3.5 M.t.a. Figure 5.15 provides a summary of the sequence in which the equipment was installed in each section of the plant as well as the annual production of each of the five sections.

Two major points can be drawn from figure 5.15, the first is that the main equipment units of the expansion plans did not start to enter into operation until 1973. As was noted above since 1965 the firm was aware that it had to increase production to a minimum of one million tons per annum in order to break even. It drew up various expansion plans involving the pur-

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(1) As was developed in the previous section the First National Expansion Plan which was launched in 1971 called for an increase of Brazilian Steel Production to 20 M.t.a by 1980 and it programed an expansion for COSIPA identical to USIMINAS, and one slighty larger for CSN which was supposed to reach 4.0 M.t.a instead of 3.5 M.t.a in 1980.

(2) In 1971 the International Bank for Reconstruction and Development and the Inter American Development Bank sent an appraisal mission to USIMINAS which approved the expansion plans to 2.4 M.t.a and led to credits from these two financial institutions covering 105 million dollars out of an estimate total cost of US$ 576 million dollars. As will be developed below, participation by these Banks affected the purchase of equipment in that they require the borrower to adopt a system of open international bidding for equipment supply.

Figure 5.13

USIMINAS - INITIAL PRODUCTION FLOW PROFILE - 1966

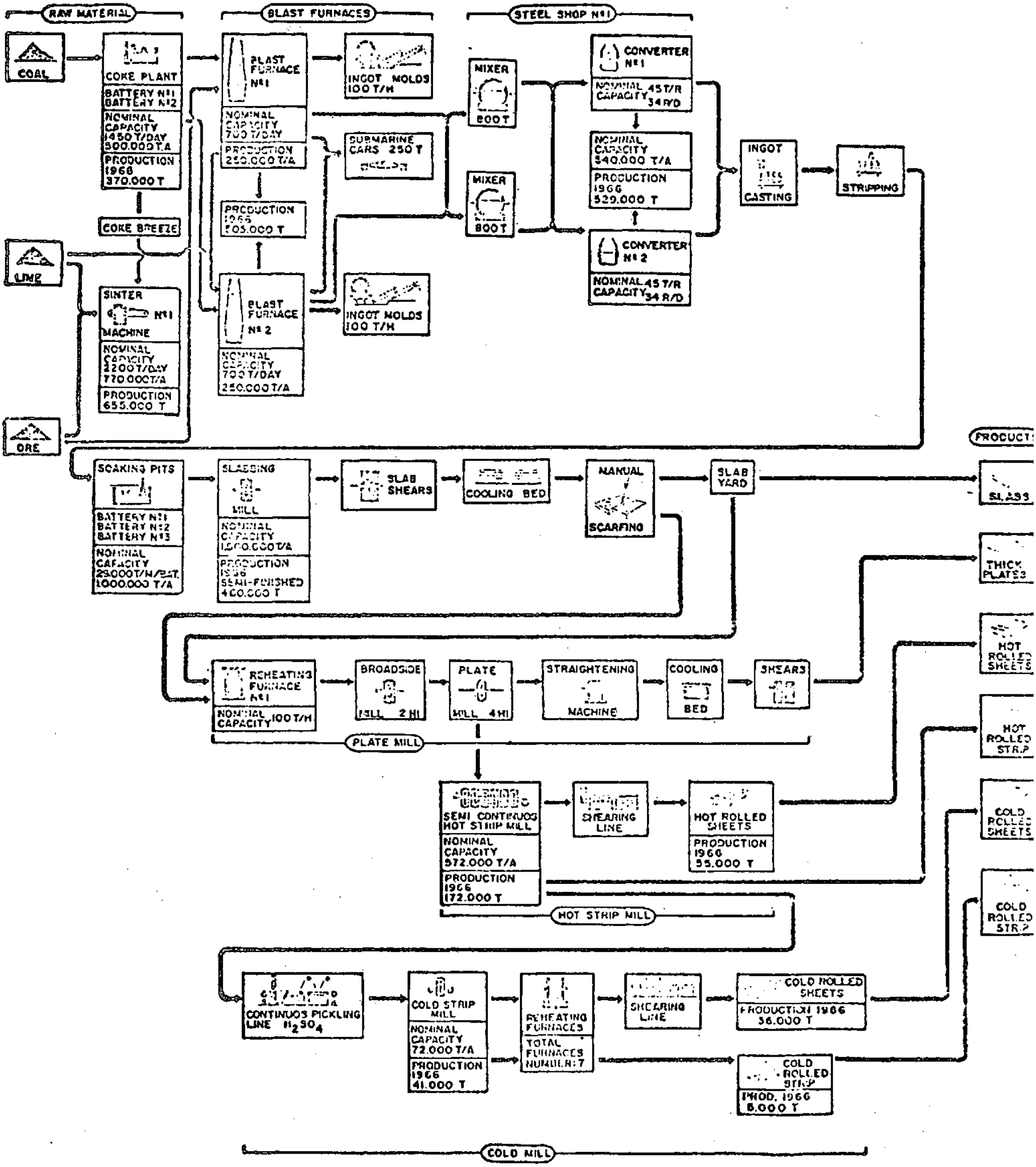


Figure 5.14

USIMINAS - PRODUCTION FLOW PROFILE - PHASE III - ESTIMATED COMPLETION - 1979/80

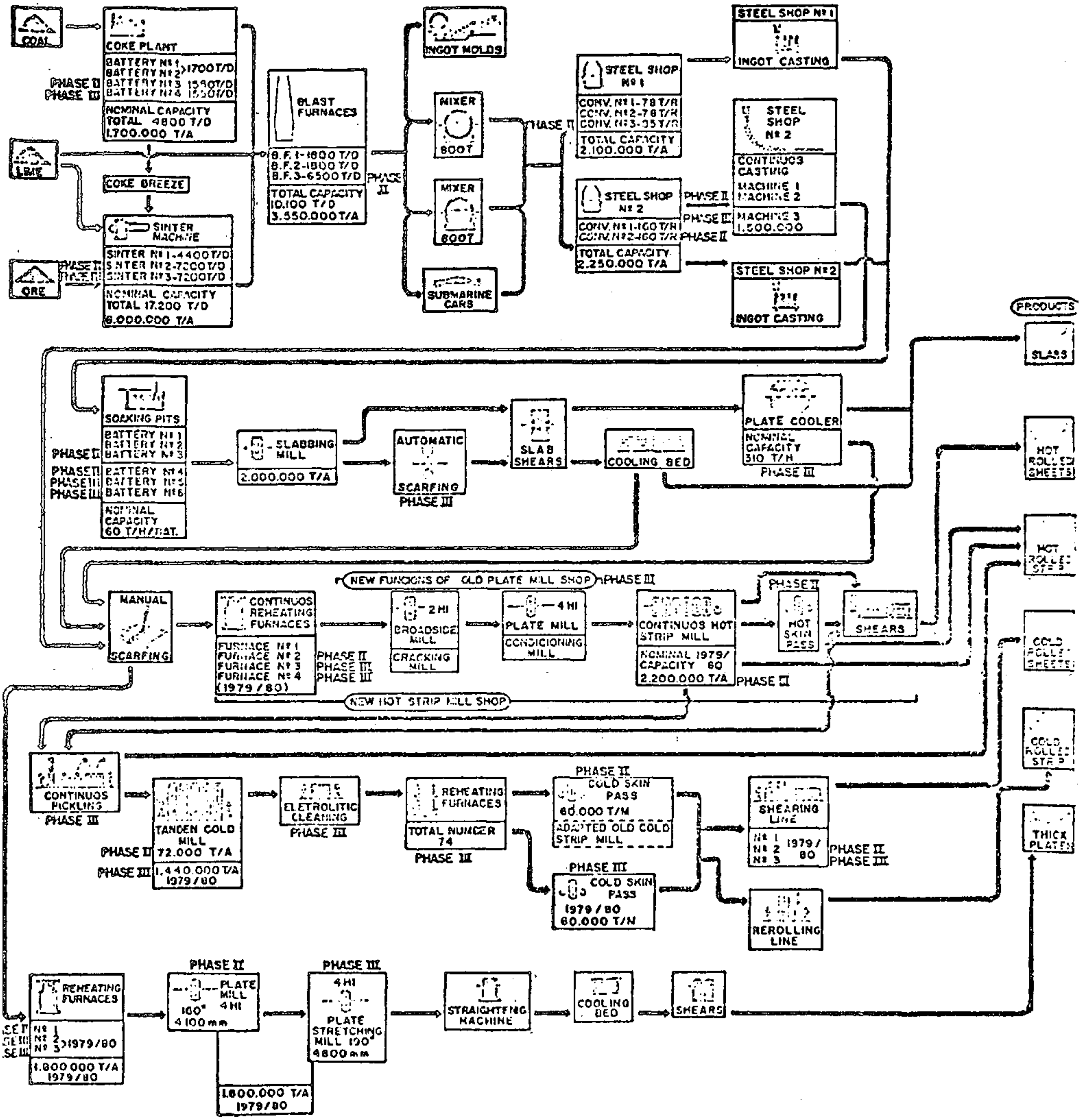


Figure 5.15 USIMINAS SUMMARY OF SEQUENCE OF EQUIPMENT INSTALLATIONS AND PRODUCTION SERIES

	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
	INITIAL PLANT 500,000 TON NOMINAL CAPACITY $US 251 MILLION ESTIMATED COST								PHASE II TO REACH 2,4 m.t.a. $US 961 MILLION IN 1975 REVISION							PHASE III TO REACH 3,5 m.t.a. $US 1,061 MILLION ESTIMATED		
COKE	No.1 COKE BATTERY			No.2 COKE BATTERY									No.3 COKE BATTERY				No.4 COKE BATTERY	
(PRODUCTION IN 1000 TONS)	44	187	197	269	369	381	405	483	534	575	613	634	604	1011	1201	1213		
SINTER		No.1 SINTER MACHINE											No.2 SINTER MACHINE				No.3 SINTER MACHINE	
(PRODUCTION IN 1000 TONS)	—	312	433	572	654	707	855	1050	1182	1286	1434	1544	1369	2871	3094	3255		
PIG IRON	No.1 BLAST FURNACE			No.2 BLAST FURNACE						No.1 BLAST FURNACE REFORM 883 m³ - 837 m³						No.2 BLAST FURNACE REFORM		
(PRODUCTION IN 1000 TONS)	34	218	270	382	505	543	600	711	751	853	1062	1197	1038	1679	2144	2465		
STEEL		No.1 CONVERTER No.2 CONVERTER										No.3 CONVERTER No.3 OXYGEN PLANT	No.4 OXYGEN PLANT	No.2 STEEL SHOP 2 x 160 CONVERTERS No.1 CONTINUOUS CASTING MACHINE	No.2 CONTINUOUS CASTING MACHINE		No.3 CONTINUOUS CASTING MACHINE	
(PRODUCTION IN 1000 TONS)	—	73	278	393	529	570	649	731	850	950	1179	1342	1187	1771	2345	2726		
ROLLING		No.1 No.2 SOAKING PITS SLABBING MILL PLATE MILL		HOT STRIP MILL COLD STRIP MILL					No.2 REHEATING FURNACE (PLATE MILL) No.3 ANNEALING OVENS			REMODELING OF PLATE MILL [illegible] SOAKING PITS SLABBING MILL [illegible] HOT SKIN PASS	No.3 REHEATING FURNACE (PLATE MILL) TANDEM COLD MILL 10 OVENS [illegible] LINE No.1 RECOILING LINE	No.4 SOAKING PIT SLAB MILL 13 ANNEALING OVENS No.2 SHEARING LINE No.2 RECOILING LINE	4,100 mm PLATE MILL	4,600 mm PLATE MILL	[illegible]	REFORM OF HOT STRIP MILL MODIFICATION COLD STRIP MILL
(PRODUCTION IN 1000 TONS)	—	19	82	159	309	342	412	512	605	710	898	1010	932	179	153	2230		

chase of new equipment, but it was not able to raise the financial resources necessary for them either in Brazil or abroad because of its very high debt/sales ratios and because of the poor demand conditions in the Brazilian Steel market. The firm was thus forced to decrease costs and expand production with virtually no investment in new equipment.[1] As can be seen in figure 5.15 and will be detailed in chapter six it was able to increase output to almost 1,200,000 tons by 1972 with basically the original equipment. This was part of a conscious strategy to squeeze as much as possible out of the existing equipment. The 1969 anual report for example, commenting on 22% increase in production of steel ingots achieved in 1969 over the 1968 level states:

> Such efforts represent the effort which our enterprise is developing to improve its profitability through the reduction of costs by way of an increase in production.(1)

It should be noted that the firm did not seem to know how much it could ultimately squeeze out of the equipment. In 1969 for example the same anual report claimed that with the 790,000 tons it had been able to produce that year it practically attained its "maximum probable production" and that additional improvements in profitability would come through greater sales receipts from the maximum production of the "noblest" and highest quality steel which gave greater returns[2]. The next chapter will explain how the maximum probable production was continually increased in the various sections.

(1) USIMINAS, Relatório Anual 1969, p.8

(2) IBID, pp. 8-9. The term "noblest" refers to higher priced steel which is usually associated with greater processing or higher qualities.

The second major point is the magnitude and capital intensive nature of the second expansion. It should be remembered from the discussion in section 5.2 that such an expansion was part of an ambitious, Government orchestrated expansion of the country's steel producing capacity. It should also be noted that the expansion received significant fiscal incentives which considerably subsidized the use of capital. The firm was thus operating in a different economic context. While the period until the turn of the decade was primarily one of a depressed market and a scarcity of investment funds, the first half of the 70's was characterized by a booming market and cheap capital for expansion. Such macroeconomic and market factors have put a definite mark on the technological development of the firm.

It is important to keep in mind that the rising production levels presented in figure 5.15 and the rising technological indexes which shall be presented in the next chapter are the results of something else which was happening within the company. Behind them was the development of an elaborate organizational and control structure. In addition the planning and implementation of the formal expansion plans led to important changes in the organizational structures of the firm. Both these changes will be discussed in chapter seven which focuses on the organizational changes behind the technological development of the firm.

CHAPTER SIX

6. TECHNICAL CHANGE IN THE PLANT

Now that the background on the creation of the firm and the context in which it has operated have been laid out this chapter examines in detail the technical change which has taken place. This shall be treated in five parts: the strategy behind the start-up of the plant, an overview of some aspects of technical change; main technical changes in each productive sector, the possibilities opened up by the large capital intensive expansion plans of the seventies, and the impact of the energy crisis on technological and productivity parameters.

6.1. Start-up Of The Plant

By way of introduction to a description of the modifications and learning which took place in the first 15 months or so of the plant's operation it is instructive to describe some initial problems with raw materials.(1)

The plant had been projected to receive iron ore with a maximum size of 30mm with 65% below 10mm. Because it was impossible to obtain ore with those specifications and because it was decided to use 100% sinter, the plant passed to use fines from Itabira. For proper sinter operation the plant specified certain standards for the chemical and physical properties of the materials with fixed tolerance for deviations. Unfortunately the mineral supplied to the plant by the Companhia Vale do Rio Doce did not fall within the permissible tolerances, particularly with respect to the SiO_2 level.(2) Varia-

(1) The material in this section it based or Moacélio Mendes and José Barros Cota. "Preparação dos Materias Primas e seu Efeito no Alto Forno da USIMINAS" METALURGIA ABM Vol. 21 nº 91 (Junho,1965) pp. 471-477.

(2) When the plan was designed there was no certainly of the exact composition of the raw materials which would be supplied.

tions in the SiO_2 level produced parallel variations in blast furnace operation and high consumption of expensive lime. For that reason, even though the installations had not been projected for homogenization, the plant was forced to develop homogenization techniques in the raw material yard and preparation stages. The need for homogenization plus the problem with the granulometric distribution of the mineral actually received versus that for with the installations had been projected caused several difficulties and bottlenecks in the raw material receiving, handling and preparation sectors. These are discussed in more detail in Appendix II. It should be noted that in a multi process operation such as steel production succeding sectors are dependent on the preceeding ones so problems in the raw materials sections have repercussions on the whole operation.

The homogenization operations carried out in the raw materials yard turned out not to be sufficient to control the SiO_2 variations so it was necessary to carry out secondary homogenization using four storage silos from which equal percentages came to be withdrawn. All of these modifications, of course, represented technical changes whose purpose was to control the physical and chemical characteristics of the raw materials.(1) We would have like to have studied these changes in more detail, particularly with respect to how, and by whom they were conceived, but we were not able to obtain that sort of information. The ones that we have identified seem to have been carried out mostly by the Japanese, for as we have already noted they were initially responsible for the operation of the plant.

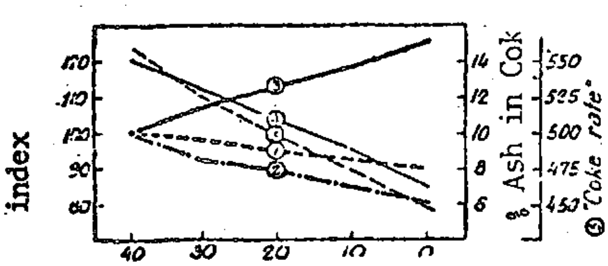
(1) Iron ore from Itabira is hematitic and is characterized by a high degree of purity, but presents a difficulty for sinterization in terms of resistance. In order to increase the resistance it is common to add various components, such as sands, rolling scarf, lime, blast furnace dust, slags, and even iron poor minerals. After various preliminary laboratory tests, USIMINAS opted for the use of granulated slag plus lime. Considering that USIMINAS's furnaces are coke based, that Itabira ore is very pure, and that about 340kgs of slag have to be produced per ton of pig iron for dessulfurizarion purposes, it is necessary to add a certain percentage of fluxes in order to produce the necessary slag. The addition of granulated slag provided slag forming elements already in a chemical-physical state which would otherwise have to be obtained in reactions of ordinary fluxing agents that would involve high fuel costs. This also meant

USIMINAS did not seem to encounter any problems, at least initially, related to quality of or variations in lime or maganese supply. However, it has had considerable problems with respect to both the quantity and the quality of the coal which it can use. In part the problem has to do with the instability of foreign supply, in part to the Government requirement that coke based steel firms use 40% national coal which is of much lower quality and much higher cost.(1)

Footnot continued from previous page

that part of the CaO_2 which would have to supplied by the lime was substituted by a much cheaper material. Granulated slag was also added to maintain the percentage of SiO_2 constant in the sinter which is necessary for maximun operational results. The addition of CaO_2 to the sinter rather than directly in the blast furnaces brings advantages in blast furnace operation not only through a better distribution of CaO_2 in the charge, but also by transfering to a previous process (sinterization where it can be done at lower cost) the dissasociation of CaO_2, giving the blast furnace a greater specific volume and saving fuel cost. Addition of CaO to the sinter causes a fall in resistance but yields an overall favorable effect.

(1) The problem with Brazilian coal is a very high ash content and a high sulfur content. The higher the percentage of ash in the coke the lower the productivity of the blast furnace and the higher the coke rate. Lowering the ash content, therefore, gives a double benefit—less coke is necessary per ton of pig iron produced, and the productivity of the blast furnace itself is increased as there is a more efficient use of its volume. The graph below shows how using decreasing proportions of the high ash Brazilian coal effects: 1) the cost of coke per ton of pig iron, 2) the price of pig iron produced, 3) the production of pig iron, 4) the amount of the ash content in the coke, and 5) the coke rate.



The source of the graph is Naoto Nakamura, "Desenvolvimento da Técnica de Produção de Gusa e Situação da USIMINAS" METALURGIA ABM Vol. 21 nº 87 (Fevereiro 1965) p. 115

Proportion of Brazilian Coal in Mixture

It should also be noted that besides being of poorer quality, Brazilian coal is more expensive than imported coal. In 1966, a ton of Brazilian coal delivered at USIMINAS was twice as expensive as imported American coal delivered at the plant.

Appendix III- treats the coal problem in more detail.

6.1.1 .The first 15 months of the sinter plant[1]

When the sinter plant started operation, very little was known about the characteristics of the Itabira fines or of their behavior in the production of sinter. Initial operation was based on previous tests on pilot plants and on the experience of Japanese technicians from the Yawata Iron and Steel Co. Production started with a minimum of imputs which were later increased in order to control and improve certain characteristics. As more intimate knowledge of the ore was acquired based on operational results, doubts were reduced and those which remained were tested in the pilot plant. In that way it was possible to obtain data which permitted modification of initial criteria in order to better attend to the demands of the blast furnaces. During the first 15 months of operation there were four distinct phases as shown below.

<u>PHASE I</u>: Characterized by no homogenization and by the addition of granualted slag (February 1 - June 3, 1963).

This period was characterized by great variations in the chemical and physical characteristics, high resistance, high FeO content and satisfactory productivity-at 25.5 tons per cubic meter-which was slighly above the nominal rating of 25 t/m^3.

<u>PHASE II</u>: Characterized by homogenization and the addition of granulated slag. (June 6-August 12, 1963).

In this period there was a fall in the variation of the SiO_2 content of sinter even though there was greater variation in that of the raw material received. This permitted use of less percentage of coke

(1) Mendes and Cota <u>Op Cit</u> pp. 478-481.

in the mixture which resulted in less FeO content. There was a fall in production. That was due not to reduced efficiency, but to the necessity of making many stops to adjust the equipment.

PHASE III: Characterized by homogenization and the addition of lime.

In order to improve the efficiency of blast furnarce operation, part of the lime previously added directly at the blast furnace was mixed in with the sinter. This caused larger variations in all the characteristics of the sinter, a fall in resistance, and an increase in the FeO content. All of these changes indicated the need for countermeasures.

PHASE IV: Characterized by homogenization and the addition of lime and granulated slag. (November 20, 1963-April 20, 1964)

To maintain stability in the characteristics of the mixture particularly the SiO_2 level, granulated slag was added and better control was established over the feeder scales from the supply silos for better measurement of proportions. A reduction in coke comsumption and of FeO were obtained and productivity was increased to 30.2 $t/m^2/day$.

As far as we could tell the plant started operation with only one shift per day and gradually moved to a three shift basis by 1965.

6.1.2. The first 15 months of blast furnace nº 1[1]

The strategy of operating the equipment in the simplest way possible in order to master its basic characteristics and then to start varying additional parameters in order to improve its performance can be seen clearly in the case of the operation of the first blast

(1) The main sources for this section are Mendes and Cota, Op Cit, pp. 481-485 and Nakamura Op Cit pp. 116-121.

furnace. This furnace entered into operation in October, 1962. In the first four months only mineral ore was used in the charge and resulted in poor operating stability due to numerours slips and "hargings" a switch was then made to 100% common sinter. After approximately nine months of operation with common sinter, a switch was made to 100% lime sinter. In both cases a more gradual change was desired in order to compare the influence of different percentages of the sinter on the productivity with the object of choosing the mix that gave the best results. That was not possible, however, for reasons beyond the blast furnace section's control. Taking the last two months of each of the subperiods in order to allow some time for the training and adaptation of the inexperienced staff to the change, the results are given in the figure 6.1 below.

Throughout this period the blast furnace was only working at 60% of capacity using only 8 of its 16 tuyeres.

The average daily production increased 17% from the first period to the second when ordinary sinter was used, but it fell about 4% when common sinter was substituted by lime sinter. Notice however that with latter substitution the amount of coke used per ton of pig iron produced, which had fallen 100 kilograms with the first change, fell another 76 kgs. Notice too how the average amount of dust produced per ton of pig iron fell from 60 kilograms to less than seven with the switch to sinter. Although average daily production was .65 tons per cubic meter of blast furnace volume in February/March of 1963, according to the chief of the blast furnace section, it was close to 1.0 by July 1964[1]. The objective was to eventually reach 1.5 tons. per cubic meter. According to him USIMIÑAS was considering adopting oil injection in 1965 when they started operating the second blast furnace if the price of oil was still relatively cheaper than coal. However, he pointed out that if USIMINAS was able to acquire coal at a lower cost

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(1) Naoto Nakamura , Op Cit pp. 121-124.

Figure 6.1.: Main Results of First 15 months of Operation of Blast Furnace nº 1

	100% HEMATITE (dec.62-jan.63)	100% COMON SINTER (jul/aug. 63)	100% LIME SINTER feb./mar.64)
COKE CONSUMPTION PER TON OF PIG IRON	738 kg/t	638.5 kg/t	562.5 kg/t
DUST PER TON OF PIG IRON	60 kg/t	7 kg/t	4 kg/t
SLIPS	136	5	4
"HANGINGS	0	0	0
AV: DAILY PRODUCTION	596 t	594 t	573 t
AV. DAILY PRODUCTION PER VOLUME OF FURNACE	.572 t/m3	.671 t/m3	.648 t/m3
% SI	.96	.72	.80
% S	.034	.029	.031
SLAG PER TON OF PIG IRON	367 t	416 t	338 t

Source: Mendes and Cota, *Op Cit* p. 482-485 they would delay the adoption of oil injection until later, unless forced to because of inadequate coal supplies.

6.1.3. The first 12 Months of The Steel Shop[1]

For the steel shop in addition to the technical information we also have some information or training which we have included for the light it throws on what was involved in starting a steel plant at a time where there was still relatively poorly prepared manpower. The first slep was a selection of workers which was done through intensive interviews and standardized tests. The workers selected in this way went through a three phase training program under the supervision and orientation of Brazilian engineers and technicians. The first phase started in July 1962 with practical classes in arithmetic and industrial security with periodic tests. According to the results, in December, 1962, fifty nine operatiors were picked for the second phase which consisted of classes on steel works, security and the operation of the rolling cranes. In February, 1963 workers were divided according to the functions they were to execute. The third phase consisted of classes on steel production, security and practical instruction on the work site under close to normal operating conditions. Depending on their particular functions operators were then worked on by Japanese technicians in a final finishing phase. By March, 1963 the first shift had been trained. The second shift was trained by May 1963. It should be noted that 60% of the personnel selected had no industrial experience.

Figure 6.2 below summarizes the results of the first 12 months of operation of the LD shop in USIMINAS covering the period June 1963 to June 1964 and compares them to those for the start of a similar LD shop in Japan (1958-1959)[2]. The data is actually for the number of runs which closely parallels production as the output per run is more of or less the same (the average increased from 53.7 tons the first

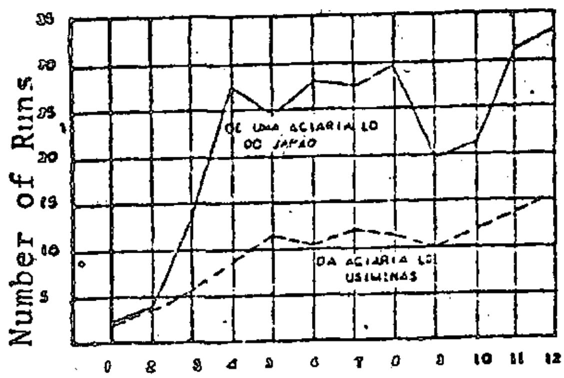
(1) Valério S. Fusaro, Et. Al "Resumo de um ano de Produção na Aciaria LD da USIMINAS" METALURGIA ABM, Vol. 21 nº 9, Julho, 1965)pp.459-469.

(2) This was a comparison done by USIMINAS own personnel.

month to 57.3 tons the 12 th month)

Figure 6.2

STEEL SHOP: AVERAGE NUMBER OF RUNS PER MONTH

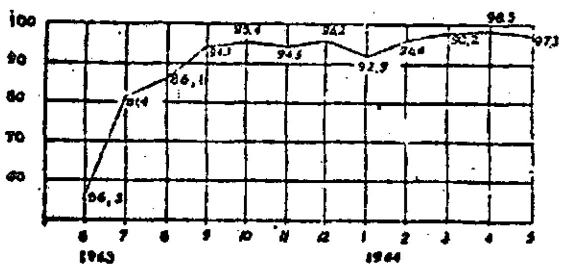


Source: Fusaro, Op. Cit p.465

Operation started in June with only one converter. The second converter started operation the next month, but work was still only on a one shift basis. Two shift operation started the following month Three shift operation did not start until April 1964. In both the USIMINAS and the Japanese case, after the third month the number of runs per day more or less stabilized. Note though that while the Japanese plant reached an average of 27 runs per day by the fourth month, USIMINAS stayed an average of only 12 runs per day and reached a maximun of only 20 by the 12th month. One reason for the much higher number of runs in Japan, apart from its longer experience and greater volume of production (Japan was already the sixth largest steel producer in the world in 1953 and has been the third largest since 1963) it that the Japanese workers were selected mainly among personnel with previous experience in S M and electric arc steel furnaces, while in USIMINAS very few had any steel experience.

In terms of actual production, by the 12th month USIMINAS was operating 18 shifts per week, as a whole day was still being reserved for preventive maintenance. Production was still only 62% of the nominal capacity rating of 42.000 tons per month. An interesting point is that between June 1963 and May, 1964 thirty nine different types of steel were produced. The degree of reproduction (degree of attainment of the targets set) since the begining of production is given in figure 6.3. .As can be see there was a continuos improvement in that index.

Figure 6.3.
Reprodution Rate for First 12 Months



Source: Fusaro, Op Cit, p. 465

Figure 6.4: AVERAGE LIFE OF LD CONVERTERS

CONVERTER Nº 1				
Campaign	Nº of Runs	Average Tons Per Run	Production (Tons)	Refractory Consup (kg/t)
1	201	54.8	11.024	10.0
2	250	56.6	14.156	7.9
3	357	56.3	20.118	5.03
4	374	57.4	21.335	5,27
5	370	63.5	23.506	5,77

CONVERTER Nº 2				
1	207	53.0	10.970	8,4
2	301	56.0	16.851	8,2
3	361	56.8	20.512	4,80
4	325	57.1	18.570	4,96

Source: Fusaro, Op. Cit., p.466

6.1.4. Conclusion on Start-up

In all three cases we were able to obtain information on it is evident that the strategy was to start with the very simplest level with the fewest number of parameters and below capacity. As the basics were mastered more turns were gradually added and progress was made toward reaching the capacity levels of the equipment. Notice too that in both the sinter and furnace cases, where productivity is more dependent on the physical and chemical characteristics of the raw materials attempts were made to learn more about the effect of those characteristics on the operation and productivity of the equipment, and to control those characteristics in order to improve performance and quality.

In all three cases it is possible to see a learning effect not only in terms of increase in overall production, but also in terms of some parameters such as productivity per relevant equipment area or volume and decrease in specific consumption of key raw materials. Although we have not been able to identify how this learning occurred. and how it came about it seems that at least in part it was accomplished due to the Japanese guidance, in part to the operational experience it self.

It is also evident that a lot of the modifications did not result from mere chance or accumulated operational experience, but were the results of carefully controlled tests and studies apart from the production line. Unfortunately, it has been impossible to clearly separate the origin of the various changes or to distinguish which seemed to occur naturally as experience was obtained from direct production, and which resulted from the specific separate studies or experiences. This was not only because our information is not detailed enough, but also because the two seem to be closely interrelated. Operational experience seemed to lead to separate tests whose results were sometimes adopted into operational practice which in turn was the basis from more tests and so on in a dynamic evolution.

6.2. Overview of Some Aspects of Technical Change

Figure 6.5. presents a set of aggregate series which give an indication of some aspects of technical change which have taken place in USIMINAS. Essentially, the series consists of steel production; employment; industrial costs as a percentage of sales; and three rough proxies for the productivity of the labor, capital, and raw material imputs. The productivity of capital is represented by the capital output (sales) ratio; that of labor by output per man employed; and that of raw materials by the coke rate(1) Examination of the series reveals that there are two distinct periods with the break occuring roughly at 1972.

6.2.1. The Period Until 1972

As noted in the previous chapter one of the most notable characteristics of the technical change which took place at USIMINAS was the stretching of the capacity of the original equipment. Figure 6.6. shows: 1) the initial nominal capacity of the original equipment, 2) the approximate time it took to reach the nominal capacity of the equipment since the start of operations, 3) output for the year before new units entered into production, 4) production in that year as a percentage of original nominal capacity. In the case of coke ovens and blast furnaces, where there were two units, we have calculated the time taken to reach nominal capacity from 1965, the year both units started operating in each section rather than from when the first unit started up.

The table shows that the greatest capacity increase occurred in the blast furnace section where production increased to 237% of the initial capacity level in seven years. It was followed

(1) The cost of coke represents approximately 70 % of the raw material costs of the production of steel in USIMINAS. (Naoto Nakamura "Desenvolvimento da Técnica de Produção de Gusa e Situação da USIMINAS", Metalurgia ABM, Vol. 21, Nº 87 (Fev., 1965), p.113

FIGURE 6.8. AGGREGATE SERIES ON SOME ASPECTS OF TECHNICAL CHARGE

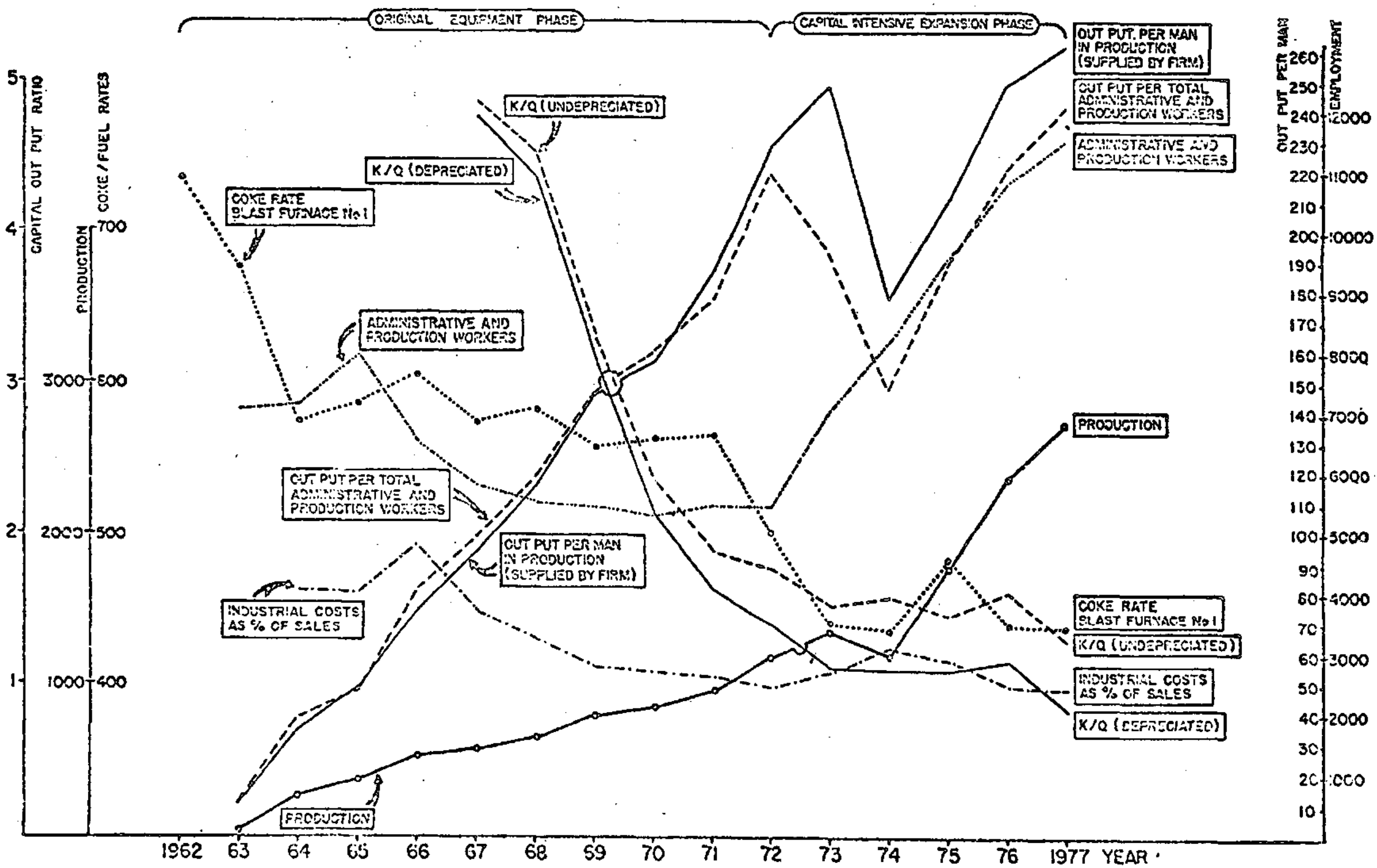


Figure 6.6. Capacity Stretching With The Original Equipment

	SINTER	COKE PLANT [1]	BLAST FURNACES [2]	STEEL SHOP
NOMINAL CAPACITY	770,000 t.a.	507,000 t.a	504,000 t.a.	500,000 t.a
TIME TAKEN TO REACH NOMINAL CAPACITY	1963-1967 FOUR YEARS	1965-1970 FIVE YEARS	1965-1966 ONE YEAR	1963-1966 THREE YEAR
PRODUCTION OF YEAR BEFORE NEW EQUIPMENT ENTERS-YEAR	1,544,000 1973	634,233 1973	1,196,803 1973	1,179,000 1972
% INCREASE OVER THE INITIAL NOMINAL CAPACITY	101%	25%	137%	134%
TIME TAKEN IN YEARS	SEVEN YEARS	THREE YEARS	SEVEN YEARS	SIX YEARS

NOTES: 1) The coke plant actually consists of two batteries with an initial nominal capacity of 725 tons per day each (253,750 ton). The first entered into operation in 1962, the second in 1965.

2) There are actually two blast furnaces with an initial nominal capacity of 700 tons per day each (252.000 t.a.). The first entered into operation in 1963, the second in 1965.

by the steel shop where production increased to 234% in six years, then by sinter section where it increased to 201% in seven years and finally by the coke ovens where it only increased to 125% in three years. The different sections had the same ranking in terms of the time it took to reach nominal capacity. The blast furnace section took only about one year, the steel shop about three, the sinter plant about four and the coke plant about five. These calculations were not done for the rolling section because of the difficulty of computing any capacity measure in view of the influence of product mix and auxiliary ovens on capacity, and the lack of disaggregated data by different pieces of rolling equipment. It should be noted that these figures are to be interpreted with caution because nominal capacity is a somewhat nebulous concept in practice because it depends on auxiliary equipment, raw materials, and specific operating conditions.(1)

The main reason for this capacity stretching was that the firm could not reach a break-even point unless it attained a minimum production of one million tons through a plant expansion which was estimated to cost roughly one quarter of the original investment. The firm was unable to obtain funds to finance that expansion so it was forced to increase the capacity of the original

(1) In particular it should be noted that although the blast furnaces had an initial rated capacity of 700 tons per day, they were based on project characteristics similar to those of blast furnace nº 2 of the Fukoaka plant in Japan which was producing at the rate of 1175 tons per day. Nevertheless, the USIMINAS furnaces suposed even the Japanese rate, as will be seen in figure 6.11.

equipment with virtually no new investments.

That it was able to squeeze more out of the initial capital invested can be seen not only from the data in figure 6.6. but also from the evalution of the two different capital/sales ratios in figure 6.5. Regardless of whether the depreciated or the undepreciated capital values are taken there is the same more or less continous decrease in that ratio between 1967 and 1972 which is the last year before major new units were installed.(1) The decrease in the capital output ratio was between 2.7 and 3.4 times depending on whether the latter or the former series is used. It should be noted that part of the reduction in the capital output ratio may have been the result of a shift in the composition of the product mix to more valuable products. As will be seen in chapter seven such a shift was part of a conscious product diversifying strategy which is a type of technical change itself.

The two series on output per man show a more than fourfold increase in productivity between 1965 and 1972. As there was very little investment in auxiliary machinery during that period, the productivity increase reflects greater efficiency in the use of labor and equipment since this is a capital dominated industry. By referring to the steel output and employment series it is possible to see that the 4.5 times increase in productivity between 1965 and 1972 was the result of the combined effects of a three-fold

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(1)1967 was used as a base year in these series because before that year it was not possible to obtain values for the equipment which were adjusted for inflation. It is possible that the inflation ~~adjustment used~~ to revalue the stock of capital was lower than the actual rate of inflation but it should be remmembered from the preceding chapter that, in general, the prices of steel products were not allowed to rise as fast as the general rate of inflation.

increase in output and a reduction of about one-third in the number of people employed. (The reasons behind the reduction in the labor force shall be discussed in chapter seven.)

The improvement in the efficiency of capital and labor reflected in the series is also due to technical change connected to the selection, control and efficient use of raw materials. The series on the reduction of the coke rate for blast furnace nº1 serves as a rough proxy for this type of improvement. Notice that it has fallen slighly over 30% between the start of production and 1972.

In terms of the evalution of costs a very rough proxy is the percentage which industrial costs(1) represent of the total sales value. This is a very indirect proxy because, as was noted in the previous chapter, the price of steel in Brazil is controlled by the Government and the price of steel was not allowed to rise as fast as costs for a substantial portion of the period in question (see figure 5.8). However, the fall from roughly 95% of sales in 1966 which was the first full year of integrated operation to 50% in 1972 would seem to indicate some improvement in manufacturing costs.

6.2.2. The period after 1972

The most notable feature in the series in the post 1972 period is the sharp trough which most of the series which

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(1) These do not include depreciation or amortization charges but that is not too serious a problem because the series on capital output ratios indirectly help to fill this gap. In fact the substantial fall in the capital output ratio imply that depreciation charges per unit have also fallen substantially

were ascending (except number of people employed) show between 1973 and 1975. In part the rough in the series was due to disruptions caused by the large capital intensive expansion plan which went into full construction during that period.[1] However, as will be seen below when we look in more detail at the operation of the blast furnaces, to a large extent it was also a repercussion of the energy crisis which led to a coal shortage that affected not only the quantity but also the quality of the coke available. This is reflected in the increase in the coke rate for blast furnace nº1 which can be seen in the series presented. Because steel production is a multistage operation such a disruption in the coke oven and blast furnace section has repercussions, all the way up through the finishing stages. In fact the severety of the crisis could be seen at the macro level in that as is shown in figure 5.1 the output of flat rolled products (which are produced by coke based plants) suffered a fall. Note too that industrial costs as a percent of sales show a rise during this period.

The fall in output per man in the 1973-1974 period parallels the fall in production but is much more accentuated because of the large increase of the number of people employed. In fact, between 1972 and 1977 employment almost doubled as a result of the more than two fold expansion of the plant.

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(1) At the MIC-CONSIDER Technology week cited earlier, then President Lanari stated that one of the greatest costs of an expansion plan like USIMINAS' was the disruption it caused in normal operations. He estimated that these could be in the order of 20%.

6.3. Main Technical Changes In Each Productive Sector

Although in general this section will present series for production and technical parameters throughout the whole period of operation of the plant, the emphasis will be on that part relating to what was achieved with the original equipment. The following two sections will develop the post 1972 period

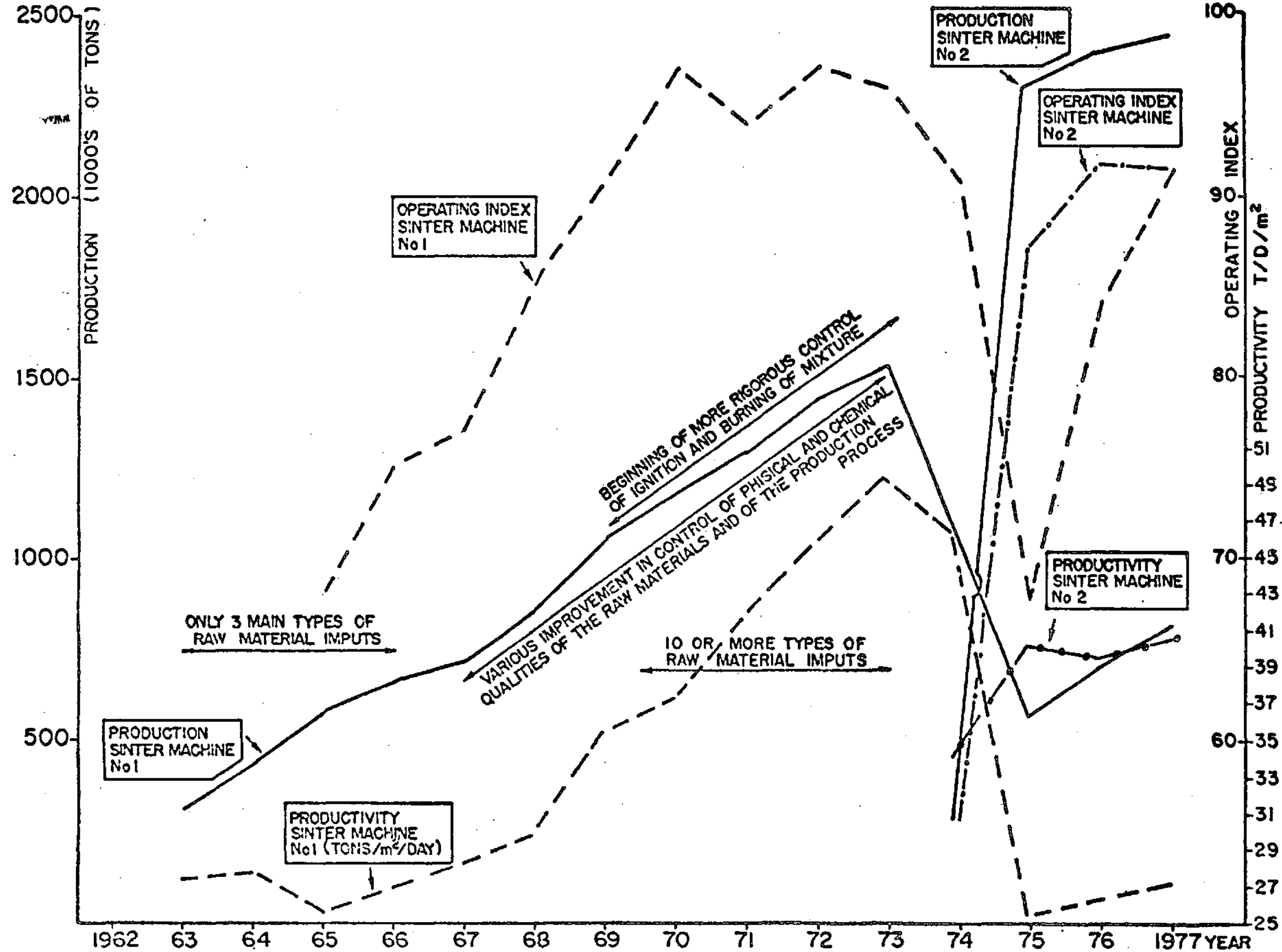
6.3.1. Sinter Machines

The basic production and operational data for the sinter section is presented in figure 6.7.[1] As can be seen from the production series on sinter, output fell in 1974 which was the year the new sinter machine came on stream. We have not been able to determine what extent this was due to the introduction to the new sinter plant. It is known that USIMINAS like the rest of Brazilian firms, faced a severe coal crisis in 1974 which not only affected the amount but also the quality of the coal which it could obtain. The decrease in quality of the coal had a significant negative effect on the productivity of the various units. Notice that while there was a continous increase in the productivity of sinter machine nº 1 between 1965 and 1973 at an average rate of 8.6% there was a fall of 6.6% in 1974 and of 48.5% in 1975 with respect to the maximum reached in 1973.

The second sinter machine which was rated at a capacity of 7.200 tons per day incorporated some modifications and adoptations based on the experience with the first machine. It entered with a productivity 70% of machine nº 1's level and although it increased 17% to 81% of that machine peak in 1973 it saffered small fall in 1976.

(1) The data on which this graph and other such grophs was based are in Appendix 8.

figure 6.7 BASIC SERIES _ SINTER MACHINES



The original sinter machine was rated at a nominal capacity of 2.220 tons per day (770.000 t.a.) based on a productivity of 25 tons/day/m^2. It was based on a Mackee design but manufactured by Mitisubishi Ship Building and Engineering Co. Ltd, who introduced some innovations of its own in the equipment having to do with the cooling system and the air blocking system. The machine was also partially adapted to Brazilian conditions in relation to the higher percentage of fines in Brazilian minerals.

The increase in production of sinter machine nº1 during the period 1963-1973 was due not only to an increase in the operating index, but more importantly to increases in productivity per square meter of machine area. Notice that although the sinter machine was operating at only 56% of nominal capacity in 1964, that was due to low operating rates, not to low productivity, as the latter was already at 100% of the 25 t/day/m^3 specified in the project.

The increases in operating rates and productivity were in large part the result of changes in type, quality and control of raw materials. As indicated in section 6.1.1., the basic strategy was to start operating with the simplest combination of imputs, master the basic operational techniques and then try to refine the techniques and the process as more experience was accumulated as a result of operation and various studies.

Figure 6.8.

SINTER MACHINE Nº 1: SPECIFIC CONSUMPTION OF RAW MATERIALS (kgs per ton of sinter 1963-1973)

Raw Material	63	64	65	66	67	68	69	70	71	72	73
MINERIO FINO	923	916	914	909	838,0	752,8	733,9	718,5	702,9	678,0	530,4
ESCALÃO FOR	64	53	43	23	30,2	41,8	37,4	27,3	20,7	13,1	0,5
CALCARIO	75	103	120	137	122,3	94,7	93,3	91,8	102,4	91,9	98,8
PO ALTO FOR					3,9	2,9					
MIN GROSSO					8,8	84,2	120,0	132,1	120,7	125,0	132,3
BITOLADO					22,4	41,7	72,9	64,0	45,6	60,1	55,4
CAREPA					27,4	38,1	20,1	15,0	22,3	25,5	30,0
PELLET ORE					2,4	10,6					
REF CAL					0,4		0,3	11,5	15,1	27,7	34,5
DOLOMITA								14,0	0,9	0,1	
ESC LD								2,2	0,8	1,7	
S DEGRADADO							0,1	2,4	37,5	[illegible]	71,9
MIN BARATINHA									3,2	0,6	31,3
SUCATA O									0,1	1,7	
QUARTZITO										2,0	4,5
MIN CONCEIÇÃO										0,1	15,0
MIN C LACERDA											12,6
S FEED											3,7

Source: Pena, Op Cit, p. 100

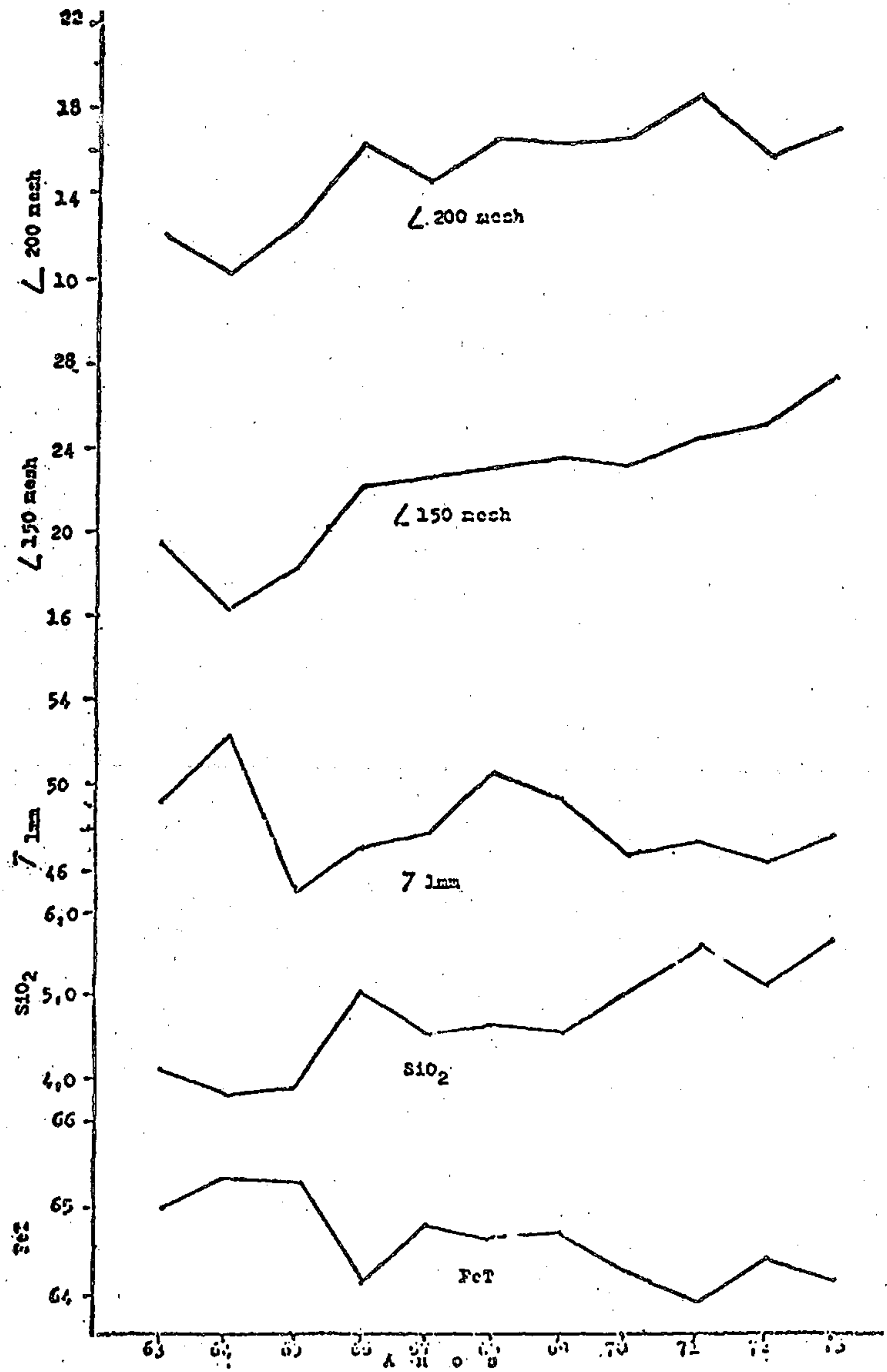
For the first four years (1963-1966) only three main types of raw materials were used - iron ore fines, blast furnace slag, and lime. As can be seen from the table presented in figure 6.8 by 1967 the number of raw materials had more than doubled. In 1968-9 the number dropped to eight although the proportions were significantly altered and there was some substituion.

From 1970 on the number of raw materials used increased continously to 13 by 1973.

Mineral ore fines are the main raw material of sinter. It contributes approximately 60% of the iron and 60% of the silica. Variations in its physical and chemical qualities significantly affect the performance of sinterization. The quality, chemical composition and physical characteristics (granulometric distribution) of the mineral ore fines received by the plant have varied significantly over the years as can be seen in figure 6.9 . The introduction of new materials has become necessary to correct the granulometric curve of the mineral as well as to give the mixture the physical and chemical characteristics needed for the sintering process to have a high productitity index with the best characyeristics for its use at the blast furnace stage. As can be seen in figure 6.8 the consumption of mineral ore fines per ton of sinter produced has gradually fallen from 928 kg in 1963 to 596 kg in 1973 due to the introduction of and substitution by other raw materials.

We do not have detailed information on who was responsible for the conception of the changes or on how they were decided. All we know is that was considerable experimentation including testing on a pilot sinter plant which USIMINAS seems to have had from the very beginning although it is now part of the recently created research center.

Figure 6'9: Variations in Quality and Size of Ore Received by USIMINAS



Source: Pena, Op Cit, p.10

is should be noted that increases in productivity to augment the capacity of an installation usually result in a deterioration of the quality of the product. In the case of sinter machine nº1, the increases in productivity were concurrent with an increase in the quality of the sinter.

In order to maintain the proper content of FeT, FeO, CaO, SiO_2 and Al_2O_3 in the sinter it was necessary not only to change the methods of control of the raw materials and the process, but also to develop new methods. These methods included not only machine related operations such as improving the dosage systems of raw materials on the feeding tables, or the size of the sinter, but also to more organizational aspects such as paying periodic visits to the raw material suppliers, perfecting the system fo blending mineral ore fines in the raw materials yard, introducing new forms for the annotation of additional control information, training of personnel (particularly of those tied to the collection of samples) and development of new ways to control basidity.

For example, in relation to the control of basidity, until June 1972 the control of (increase in) SiO_2 content was done through addition of blast furnace slag. However, the slag contained 17% Al_2O_3 which had adverse effects on the performance of the sinter in the blast furnace. In July, 1972 the technology of using fine quartzite to attain the content of SiO_2 desired in the mixture was introduced. After realizing several tests and obtaining access to sufficient fine quartzite, it was possible to to stop using blast furnace slag and to switch to the use of fine quartzite (November, 1972) which did not have the negative secondary effects. To reduce the content of SiO_2 when it was too high, in 1973, USIMINAS developed a system of adding mineral ore from Barantinha whose SiO_2 content is very low.

With respect to control of the size of the sinter a new system of screening was introduced in Austust 1967 in order to reduce those fractions below 5mm which are not recommeded for blast furnace operation. In addition, a roll crusher which was available as a result of some of the modifications in the coke charging operations for the blast furnace was installed for the preparation of sinter. After variou tests, in December 1972 it was installed in the sinter preparation cycle. With these two measures the average size of the sinter was reduced to the desired levels.

In addition to changes in the type, quality, and control of raw materials, a second general type of change which was responsible for the increase in productivity was increases in yield. These were primarily related to reducing the amount of return as a large part of sinter produced usually has to be recycled through the machine again because it does not fullfill the size characteristic required. The factors which contribute to an increase in yeild are intensity of ignition control of coke, and control of screening.

Until 1969 the conditions of ignition of the mixture to be sintered were not satisfactory. In fact, there was no rigorous control. However, from 1969 on, due to the increased need to augment productivity in order to satisfy increased demand from the blast furnaces, attention was focused on obtainning maximum burning efficiency in order to reduce the amount of material which did not attain the required size. Initially, this was attempted through a change in the diameter of the gas pipes and of the gas jets in order to increase the volume of gas supplied. In spite of these modifications the desired intensity of ignition was not achieved, particulary considering that an increase in the velocity of the conveyer sheet was planned. To increase the intensity of ignition to the desired level a second ignition oven had to be introduced in August 1973.

Together with the increase in ignition intensity better control of the coke fuel was sought in order to reduce it to the minimum for the maximum of efficienty. The proper granulometric distribution of the coke is fundamental for this optimization. Both the proper preparation of the coke and it proper distribution in the sintering machine are essential. Tests were conducted to chose the ideal granulometric distribution. As the distribution is a function of the coke preparing equipment more rigorous control of that stage as well as several modifications in the equipment were necessary.

Studies also showed that a large part of the material which returned contained a high percentage of sizes which could be used. To solve this, the size of the screens was changed to more adequate dimensions and closer control of their condition and wear was set up. Through these measures, which started taking place in 1971, it was possible to obtain a greater yeild of the process due to a reduction of the volume of the return.

More details on the evolution of sinter machine nº 1 before the introduction of the new machine are available in Appendix II. The purpose of the material included here has been to show three basic points. First of all, the evolution has been piecemeal and gradual with the focus of attention passing from one aspect to another. Second, most of the initial effect was devoted to learning about the basic process itself , particularly the influence of various physical and chemical qualities of the process. As these were learned greater efforts were directed at controlling the basic characteristics of the raw materials. In large part this involved reaction to the variations in these qualities in the raw materials received. (Reactions to external fluctuations). Third, as more experience was gained, better methods were developed, including not only changes in raw materials used, their handling preparation, weighing, etc., but also of the process itself. To do this it was necessary to not only modify or add various pieces of equipment but to develop new organizational methods involving training, learning, and studying various aspects of the process.

6.3.2. Coke Plants

In the coke section, USIMINAS' project called for the use of two 50 oven coke oven batteries based on the type used by the Japan Iron and steel Co. They were each supposed to have nominal capacity of 725 tons per day. The first battery entered into operation in 1962. The second battery was not able to enter into operation until 1965 due to an insufficient supply of coal caused by inadequate unloading facilities at the port of Vitória through which USIMINAS received both domestic and imported coal. A third coke plant entered into operation in 1974 with nominal capacity of 1345 tons per day. A fourth coke plant similar to the third plant is supposed to enter into operation sometime during 1978-79.

For the evolution of the coke plants we have no information except for the series presented in figure 6.10. Compared to the improvements achieved in the other sections those in the coke plants have been relatively modest. Nevertheless, the operating index of the coke batteries has always been 100% and they always worked at close to the international standards.

Note that output of the first plant fell the year the second plant entered into operation.

6.3.3. Blast Furnaces

The basic series on the evolution of the blast furnaces is presented in figure 6.11. As explained in section 6.1.2. only blast furnace nº 1 was used initially. The second blast furnace did not enter into operation until 1965 due to coal shortages caused by deficiencies in the unloading facilities in the port of Vitória.

figure 6.10 BASIC SERIES _ COKE PLANTS

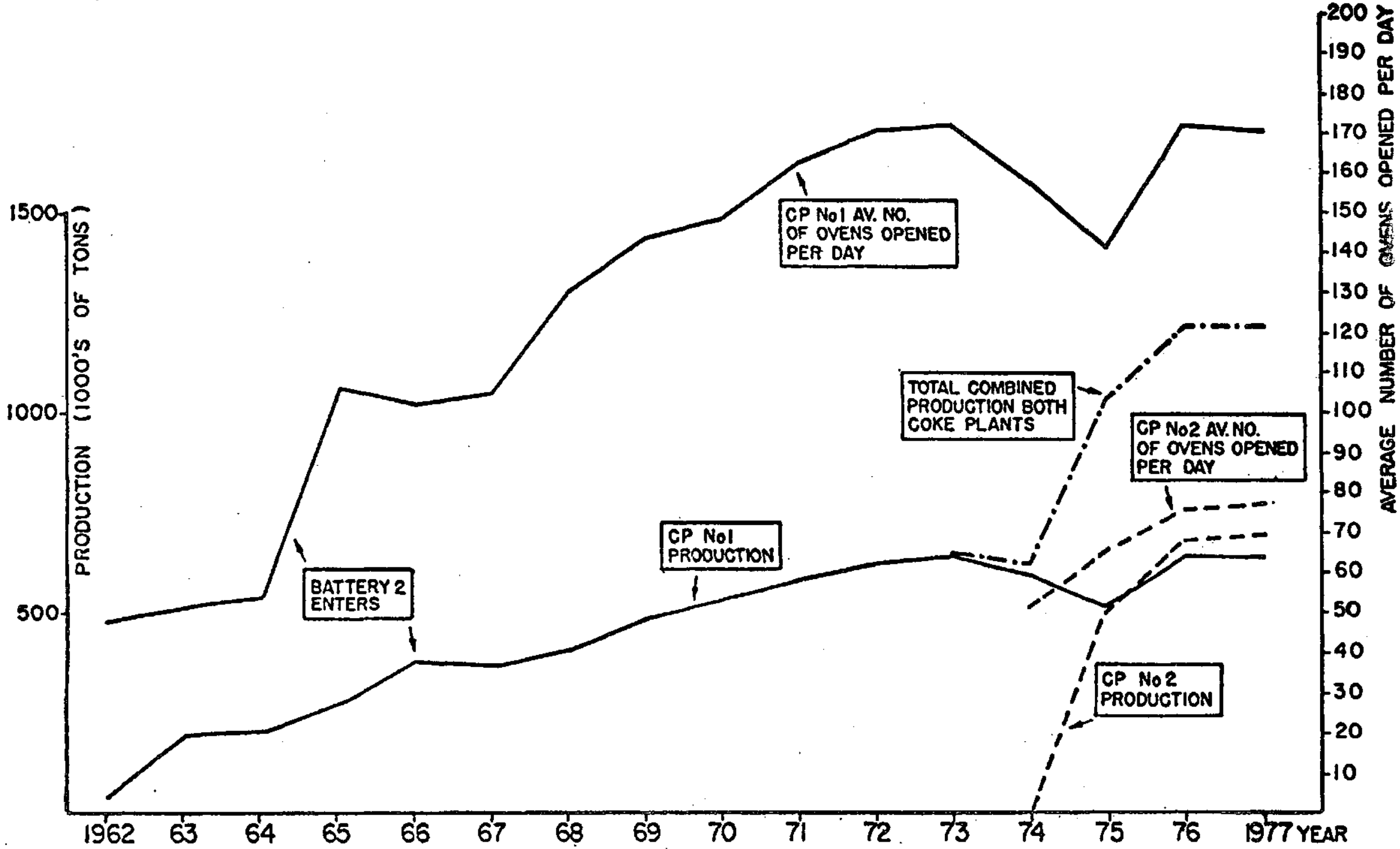
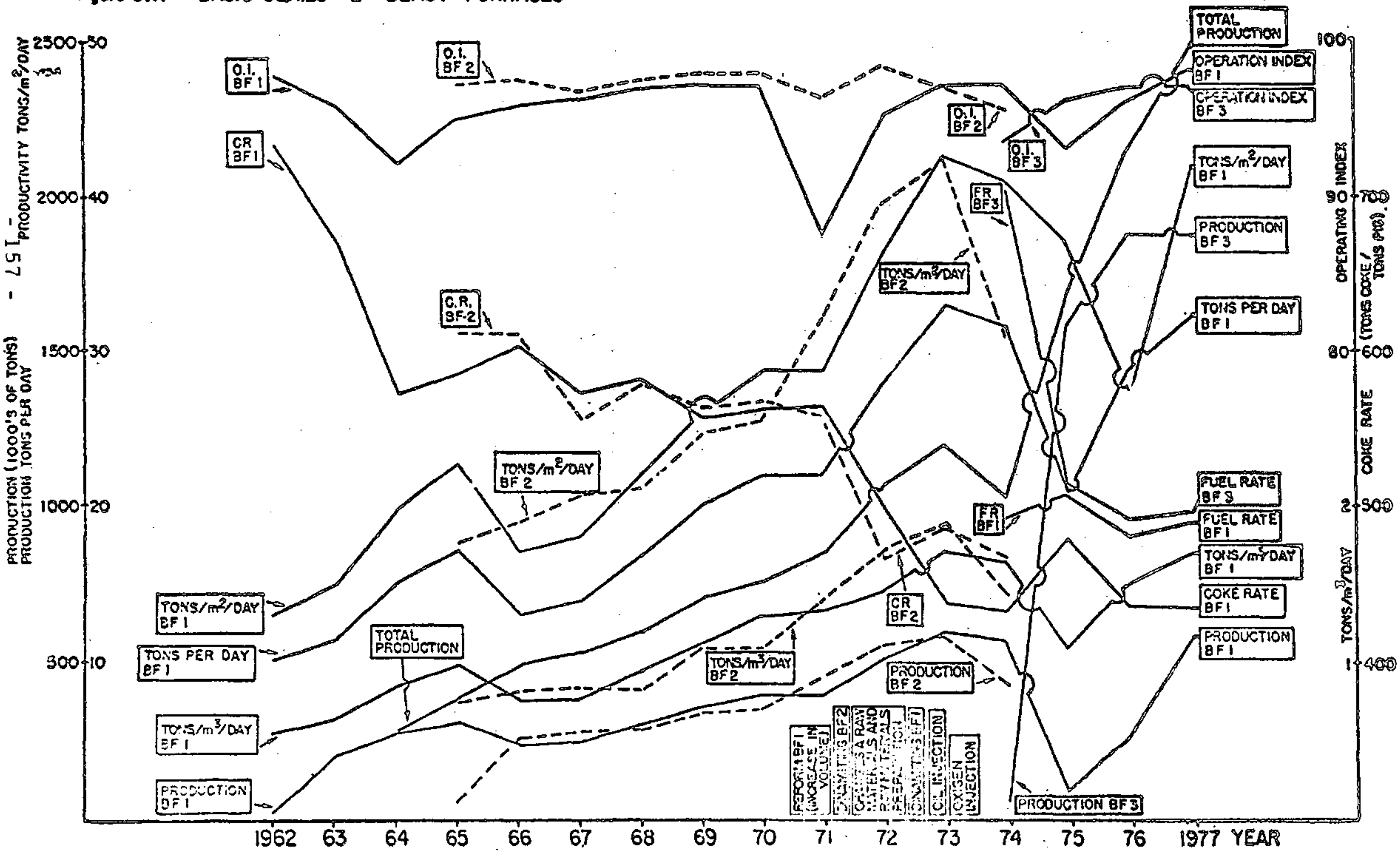


figure 6.11 BASIC SERIES _ BLAST FURNACES



A third blast furnace entered into operation in December 1974. It had an initial rated capacity of 5.900 tons per day (2,100,000 t.a.) which apparently is going to be increased to 6.500 tons per day through the addition of a fourth Cowper type regenerator. Once this large blast furnace entered into operation USIMINAS stopped blast furnace nº 2 from December 1974 to March 1978 for a complete reform to enlarge its internal volume from 885 m^3 to 1090 m^3. Notice that as in the case of sinter, production fell the year the third blast furnace entered into operation. Once again we have not been able to separate out the effects of the coal crisis from any related to the preparation for and initial operation of the new blast furnace.

In terms of both production and coke rates, there has been considerable jocking back and forth of the performance of two original furnaces which are identical except for their different start up dates. When the second blast furnace entered into operation in 1965 there was a fall in the output and a worsening of the coke rate of blast furnace one which did not recover until 1968. It has not been possible to identify to what extent this was a result of problems in the availability or quality of coal as opposed to initial disraptions caused by the simultaneas operation of the two furnaces.

Unfortunately, we do not have any information of how production was increased 17.8% between 1968 (1) and 1969 or of how the coke rate was further reduced from the low levels attained for blast furnace nº 1 in 1964. However, we do have information for the changes which took place during the four year period 1970.1973 (2). Fortuna-

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(1) 1968 could be considered the normal level as it is close to that achieved in 1965 with the first blast furnace.

(2) This is based on Lauro César de Abreu, Et. Al. "Evolução da Produtividade dos Altos Fornos da USIMINAS" Contribuição ao XXIX Congresso Anual da Associação Brasileira de Metais, Porto Alegre, R.G. do Sul, julho 1974.

tely this is a very interesting period as it covers the first reform of blast furnace nº 1 and the dinamiting of the deposits (scaffold) which built ap inside both furnaces.

To show the effect of various of the measures the period between 1970 and 1973 has been divided into four sub-periods. The first period (January 1970 to January 1971) was characterized by the irregular operation of the blast furnaces both of which had built up scaffold. The irregularity of operation can be seen by the high average number of average slips and "hangings" during this period. (See figure 6.12). This was attributed to use of coke of lower mechanical resistance due to the lack of low-volatile coal in the mixture and to lower quality mineral. It should be noted, however, that production (and productivity per volume) for each of the blast furnaces was more twice the maximum that had been reached by the first blast furnace during its first 15 months of operation. The highest then reached, (July, 1963) had been 18.414 t. versus an average of 30,217 t. for blast furnace nº 2 and the slightly higher average of 33.395 t. for blast furnace nº 1 .This indicates that there must have been significant technical changes during the intervening period of which we, unfortunately, have no knowedge. Notice though that average coke consumption in 1970 was not significantly different from the levels achieved by the end of the first 15 months of operation of the first blast furnace. To the extent that coke consumption can be taken as an index of costs since it usually accounts for 53% of costs, this would seem to indicate that average material production costs had not changed too much unless other operation or raw material costs had been significantly reduced. Overall costs may well have decreased in view of the better utilization of the equipment and labor which is implied by the much greater production per furnace.

During the 13 month sub-period in question various measures were taken to try to improve the operation of the blast furnaces particularly of blast furnace nº 2 which had more irregular operation leading in fact to various stops. Among the measures taken to improve

Figure 6.12 e : Sumary of Operation of the Blast Furnaces-1963-1974.

		"Best of first 15 months operation Blast Furnace nº 1 (July/August 1963)	January 1970 January 1971 (13 months)	June 1971- January 1972 (8 months)	May 1972 - July 1973 (15 months)	August 19 December 19 (5 months)
Coke consumption						
Per ton of	Bf1	639	565	546	458	424
Pig Iron	Bf2		580	544	446	414
Oil Rate	Bf1	-	-	-	39	60
	Bf2	-	-	-	44	57
Oxygen Injection	Bf1	-	-	-	-	2.280
	Bf2	-	-	-	-	1.949
Average Slips	Bf1	5	260	240	2	1
	Bf2	-	174	56	3	13
Average "hangings"	Bf1	0	55	62	0	0
per month	Bf2	-	176	8	0	0
Average Monthly	Bf1	18,414	33,395	40,977	48,278	53,000
production	Bf2	-	30,217	40,839	47,534	53,107
Av. Daily						
Production per	Bf1	.67	1.45	1.40	1.69	1.81
cubic meter	Bf2	-	1.29	1.51	1.76	1.96
Average Operating	Bf1	-	97.0	97.9	97.2	97.1
Index	Bf2	-	97.7	97.0	97.5	97.8

Source: 1963 - Figure
1970-1973 - Computed from monthly data in Abreu Et Al, Op Cit

control and results were modifications in the sampling and analysis of raw materials, use of 100% sinter, increase in the coke base and a reduction in the ratio of ore to coke, change in the dimensions of the coke screens, and alteration in the level of the charge and in the charging sequence.Nevertheless none of thes measures were very effective.

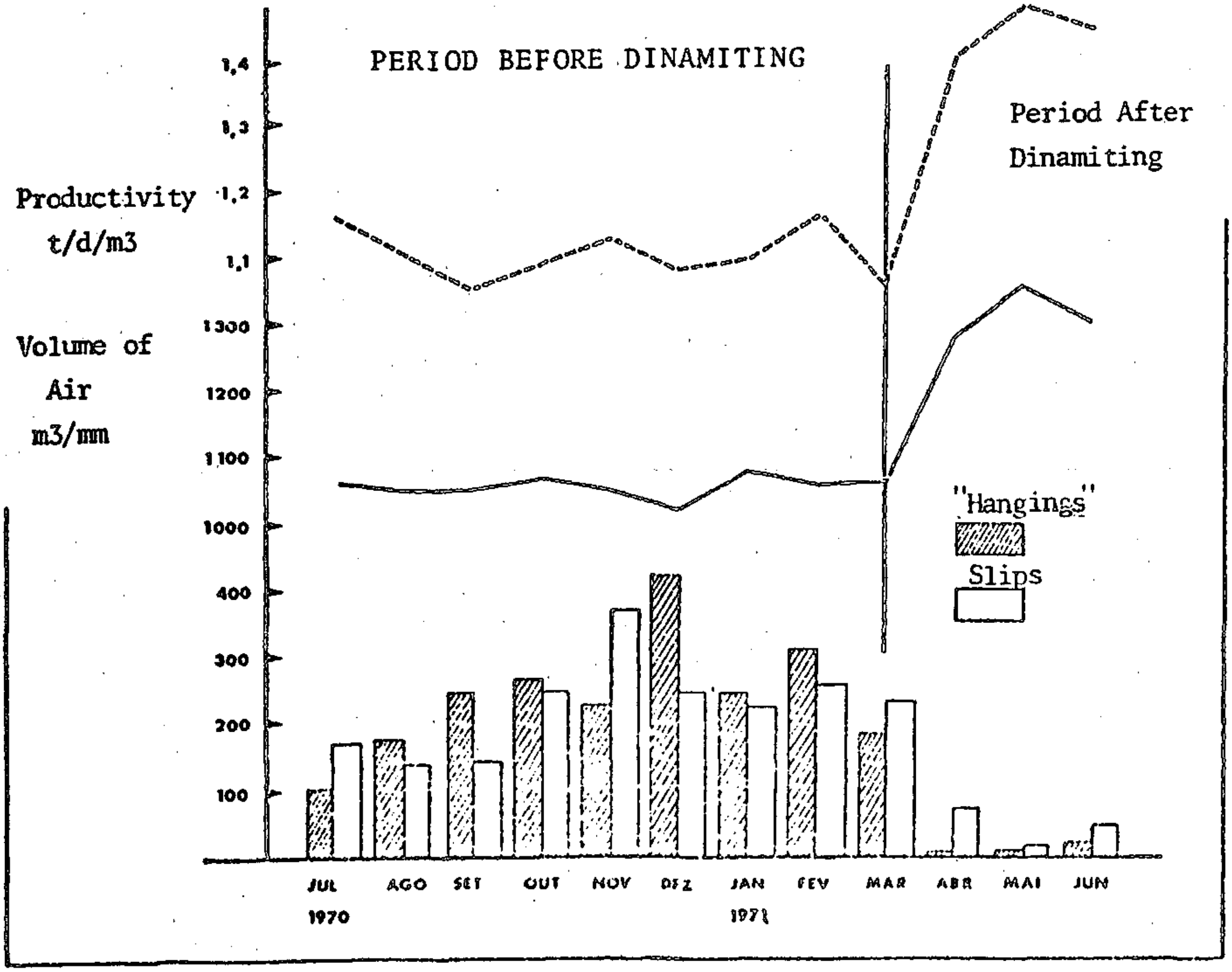
In March and April 1971 blast furnace nº 1 was stopped for a major programmed overhaul. A commision for the reform of the blast furnace had been created as far back as 1967 with the participation of members of the Department of Engineering, Coke, and Blast Furnaces.This commission coordinated and accompanied the reform work and wrote the final report on the reform. It relied on support from the technical department and on technical assistance from Nippon Steel and Ishikawajima Harima Heavy Industries (suppliers of the furnaces) and others. The purpose of the reform was to increase the productive capacity of the blast furnace which was necessary to balance existing equipment capacity in various sections in order to meet the production goals set in the first expansion plan. The reform consisted of a substitution of the whole refractory lining of the furnace which permitted an increase in useful volume from 885 m^3 to $957m^3$. Various pieces of auxiliary equipment and facilities were also modified or substituted by others with better performance or greater capacity. Workers were subcontracted through Montreal Engenharia S.A., a local engineering firm. Unfortunately, we were not able to obtain any figures on the cost of the reform or on the relative participation of USIMINAS versus foreign personnel in the various phases of the project from conception to implementation. However, it seems that the foreign participation was relatively high at least in the planning phase.

It is interesting to note that for the second period although average production of the blast furnace increased as a result of the expansion in area, the productivity per cubic meter did not change much, which is striking in view of the significant increase in the productivity per cubic meter of blast furnace nº 2 during the same period.

With respect to blast furnace nº 2, the lack of sucess of the various measures described led USIMINAS personnel to conclude that the most viable alternative to increase productivity was to eliminate the scaffold by dinamiting. A preliminary investigation done by drilling through the walls of the furnace showed that the build-up of deposits was indeed very serious, particularly in view of the fall of production which would result from the stoppage of blast furnace nº 1 for reform. The need to eliminate all the deposits plus the highly dangerous nature of removal operation led USIMINAS to contract the Japanese firm Nishinkogyo KK which had long experience in that type of work and had done almost all the dinamiting for Japanase blast furnaces. The dinamiting was carried out in March and April of 1971 while the furnace continued in operation. The removal of the deposits by dinamiting resulted in a dramatic reduction of the slips and "hangings" and in an increase in the blast rate which resulted in record indexes of productivity as can be seen in figure 6.13 . According to USIMINAS the cost of the dinamiting operation was repaid by the increase in production (about 30%) which was obtained in 35 days after the first dinamiting.

Data on the second sub-phase (June, 1971-January, 1972), which starts one month after the reform of the first blast furnace and the dinamiting of the second, showed an increase in average monthly production of 23% for the first furnace and of 35% for the second. After some months of operation, however, blast furnace nº 1 started showing irregularities in operation (see the higher average number of slips and "hangings" for that period in figure 6.12) which were identified as beening caused by new deposits inside the furnance even though it had just been relined. These deposits were very different in terms of type, size and localization from those which had been removed from blast furnace nº 2. They were removed through various prolonged and repeated stops in the months of February, March, and April of

Figure 6.13 : Productivity, Volume of Air, Hangings and Slips Before and after Dinamiting Blast Furnace nº 2



Source: Vanderlei Antunes Guimarães and Benedito Sozinho de Souza Filho, "Eliminação do Cascão do Alto Forno nº 2 da USIMINAS" USIMINAS REVISTA Ano 2 Nº 4, pp. 5-2

1972 As far as we can tell these were carried out by the USIMINAS personnel themselves based on the experience they had learned from the technical assistance contract with Nishinkogyo KK for the dinamiting of the first blast furnace a year earlier.

The better performance in the second period was not the result of just the two reforms already mentioned. A series of other measures were also taken during this period. Among them were various changes in raw materials and raw materials preparations(1), introduction of a ten year plan for the blast furnaces which permitted greater standarization of operation (2) reductions in variation in charging proceedure, improvement in auxiliary equ pment(3), and the introduction of new equipment.(4)

Data for the third sub-period (May, 1972-July 1973), which starts after the dinamiting of the deposits in the first blast furnace, showed a normalization in the operation of both blast furnaces. During this period a number of technical changes were implemented. One hundred per cent of the sinter was screened which permitted greater control of the granulometric distribution of the sinter. Also based on various tests which showed that the use of pellets increased productivity per volume and reduced the coke rate, pellets started to be used to complement the metal charge. A central operation control was introduced which permitted probing the gas conditions of the oven and made possible alterations in the weight of the charge and other parameters affecting the distribtution of the gas Through the use of up to 50% coke oven gas in the regenerators, the blast temperature was increased 100°C which permitted greater thermic efficiency. Various improvements and adaptations were made in the operation of the char-

(1) Introduction of screening of 50% of the sinter in the silos of the blast furnaces, use of non-calcinated carbonate in the mixture (because studies done by USIMINAS showed that greater use of non-calcinated carbonates reduced the coke rate).
(2) This involved the introduction of various controls such as of the state of the blast furnace profile, the tuyeres, etc.
(3) Improvement in the refrigeration of the valves, in the refractory etc.
(4) Coke gas mixer for the regenerator 5 vibrating screems for the sinter, 2 vibrating screens for the coke.

ging equipment which significantly improved control, reduced irregularities and increased capacity. Also, various new pieces of auxiliary equipment were installed(1) which permitted greater control of the physical characteristics of the charge. The most significant technical change, however, seems to have been the installation of a system for oil injection. These measures permitted a reduction of about 90 kgs. in the coke rate with the use of about 40 kgs of fuel oil. In addition average monthly production for this period increased 18% and 16% for blast furnace nº 1 and blast furnace nº 2 respectively, as compared to the previous period. Unfortunately, we were not able to obtain any detailed information on the costs of the various modifications, their cost, or how they came to be implemented. Oil injection was adopted with the technical assistance of the Japanese(2), and it is estimated to have led to a reduction of 404 million cruzeiros per year in the cost of pig iron production(3)

The fourth sub-period (August-December, 1973) was also characterized by normal operation of the blast furnaces and by the increase in productivity per cubic meter of furnace volume. Average monthly production increased approximately 10% for blast furnace nº 1 and 12% for blast furnace nº 2. The coke rate fell about another 30 kgs., although oil injection increased by about 20 kgs. (See figure 6.12). The technical change which was in large part responsible for these changes was the introduction of oxygen injection which started in August with up to 2.5% oxygen enrichment . This permitted oil injection to increase to 60 kg.with a consequent reduction in the coke rate. For each 1% of oxygen enrichment there was a close to a 5% increase in production with an increase in oil consumption in the order of 8 kgs., and a reduction

(1) Five more vibrating screens plus a secondary crusher for the sinter.

(2) This was through the general technical assistance contract USIMINAS had with Nippon Steel (see Chapter 7)

(3) We could not determine which year the monetary value referred to.

of the coke rate of 12 kgs. Besides the introduction of the auxiliary equipment for oxygen injection, various improvements in existing equipment (1) and in the preparation of the charge were made.

A quick sumary index which is a good indicator of the improvements achieved in the use of raw materials and in the introduction of auxiliary technologies are the indexes tons product per square meter per day and output produced per day. Until 1971 the improvement in the tons/m^2/day which rose from 13.1 tons/m^2/day and 17.7 tons/m^2/day to a plateau of 28.7 tons/m^2/day and 32 tons/m^2/day for blast furnaces nº 1 and nº 2 respectively were almost exclusively due to the effort to improve raw materials. The introduction of oil injection in 1972 lead to a jump to 36.2 and 39.4 tons/m^2/day respectively. This was further increased in 1973 with the introduction of oxygen which permitted an increase in temperature and a greater amount of oil injection. That led to a productivity of nearly 43 tons/m^2/day.

Although there are serious gaps in our knowledge of what was done during part ot the period, and although we do not know much about the actual conception and implementation of the changes, several points do stand out in the information we have gathered. First of all, as in the sinter section, the proceedure has been to start slowly, trying to keep control and operating proceedure to the basics and then to slowly build up from that base as that phase is mastered and experience indicated which factors should be controlled or improved. Second, technical change seems to have occurred gradually but continously, steadily improving the average monthly productions possible with each furnace. As was shown above, the production of the blast furnace nº 1 increased more than 200% between the best figure for the first 15 month start-up period and 1970, the first year for which we again have disaggregated information. Then, in the three years beween 1970 and 1973, as a result of innumera-

(1) New oil injection lances were tested, external refrigeration for the shields of the furnace was adopted, thermocouples were adopted to accompany the wear on the walls.

ble technical changes, average monthly production steadily increased further such that by the end of 1973 it was 59% greater for blast furnace nº 1 and 76% greater for blast furnace nº 2. With respect to the highest level of production reached in the first 15 months of blast furnace nº 1's operation, this represents an increase of 188%. Third from the more detailed analysis spanning technical change during the four years 1970-1973, it was evident that technical change proceeded simultaneously among many fronts involving the preparation of the charge, greater control of the process, modifications of auxiliary equipment, substitution or addition of new equipment, and changes in operating procedure. Fourth, it is also evident that in a process as complex as the operation of a blast furnace, it is difficult to separate out the effect of just one change due to the strong interdependence among various operational parameters and to their constant and everchanging evolution.

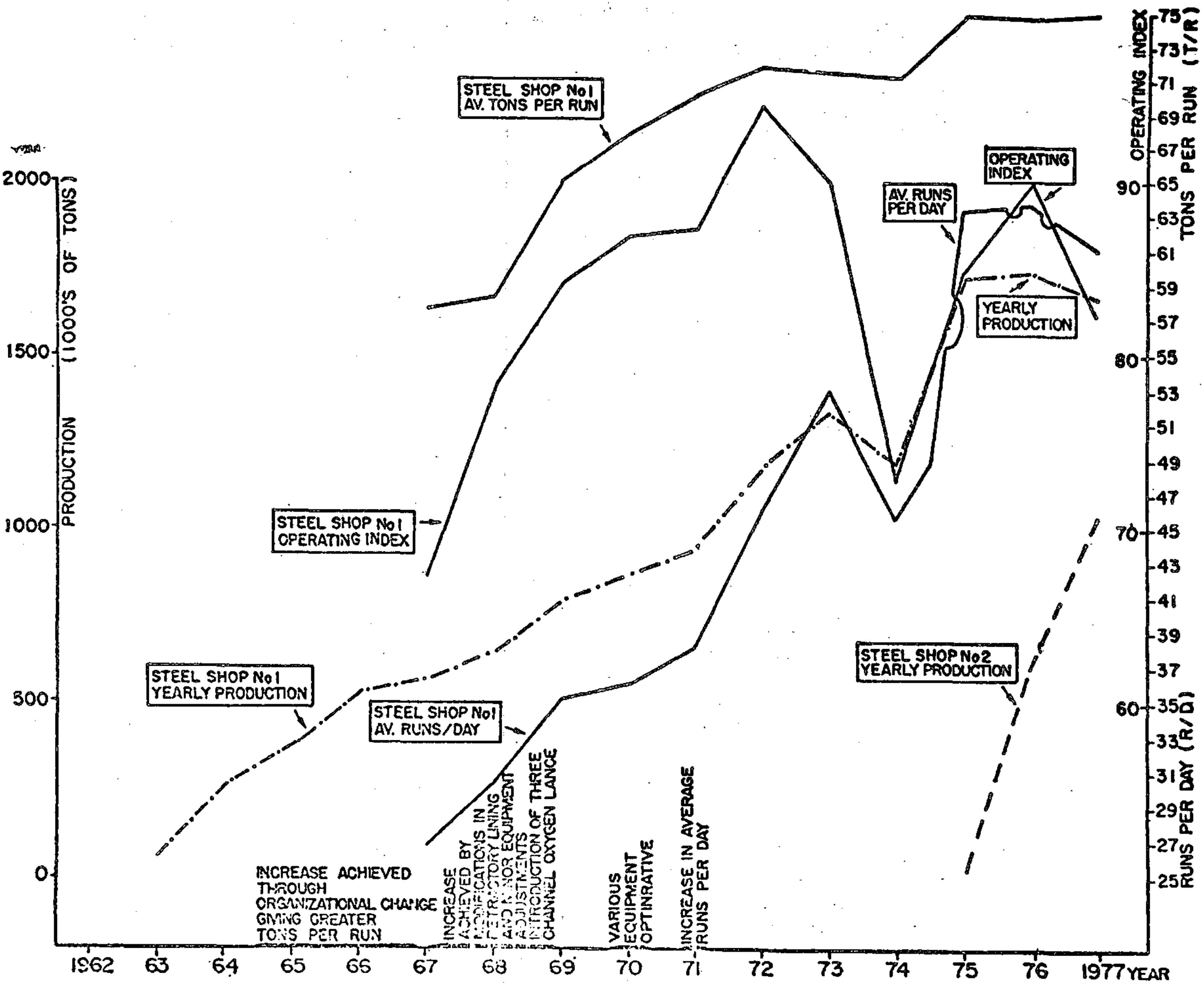
Fourth, it can be seen that pressures to keep up with the capacity expansions of other departments have been important in stimulating productivity in the blast furnace section. The important of pressures for overall sectional balance will be discussed in further detail with respect to expansion plans. Finally, the example of contracting specific technical assistance such as dinamiting the scaffold which had formed in the second blast furnace and learning from that experience such as to be able to do the process independently the second time around shows an excellent absoptive capacity.

6.3.4. Steel Shops

In the steel section USIMINAS started with two BOF converters with a useful volume of 48 cubic meters and a capacity of 50 tons per charge.They gave the steel section an initial nominal capacity of 504.000 t.a.. In September 1973 a third BOF converter with a useful volume of 62 cubic meters and an 85 ton capacity per charge was added. In September 1975 USIMINAS added a second steel shop with two BOF converters, each having a useful volume of 143 cubic meters and a capacity of 160 tons per charge. The capacity of this second steel shop was initially set at only 1.000.000 t.a. probably because of bottlenecks with the continous casting section which started with just two casting machines although a third is to be added in 1978-1979 as part of the current expansion to 3.5 M.t.a.

Figure 6.14 presents the evolution of the main series for the steel shops . As indicated in section 6.2.3. the first year of operation of the original steel shop was devoted mostly to getting the section going with three shifts per day with the two converters. The first year of operation also showed that the steel shop was going to be one of the main production bottle-necks. By 1966 it reached nominal capacity. From then on, we have been able to identify four stages in the evolution of its capacity[1].

Figure 6.14 BASIC SERIES – STEEL SHOP



Nominal capacity was increased to 600.000 t.a. by June,1967 That was achieved mainly through the increase of the average runs per converter from 56 t. to 58 t. and by an increase in the amount of oxygen injection. The increase in tons per run was achieved by a purely organizational change. The initial criterion of fixing the weight of the run at 56 tons meant that the charge had a weight varying from 59.5 to 63.0 depending on the type of steel to be produced. This meant that the full volume of the converter was not always adequately used The change involved fixing the weight of the charge at 63 tons regardless of the type of steel to be produced, which meant that the weight of the runs was different for each steel, but that more steel could be produced as the equipment's capacity was been utilized more efficiently.

In a second stage, capacity was increased to 700.000 t.a. by April 1969. USIMINAS first studied how its converters compared with those of 16 U.S. plants in terms of characteristics and production.The study showed that greater production was possible with only minor modifications in the refractory lining of the convertors and a change in the relationship between the height of the oxygen lance and the steel in the converter. To handle the larger production resulting from these changes, however, it was necessary to modify certain other auxiliary installations such as the power of the tilting motors, the gearbox the brake, the capacity of the steel laddle, and to increase the speed of ingot pouring in order to maintain the operational equilibrium between the cycle time of the ingot casting crane and the tap to tap of

(1) This is based on Antônio Augusto de Andrade Oliveira and João Augusto Machado Caldeira "Etapas de Desenvolvimento da Capacidade de Produção da Aciaria da USIMINAS (Aciaria nº 1)" USIMINAS REVISTA Ano 1 nº1(1969)pp.s-14-s.20.

the converter. Although we do have any details on who was responsible for this idea, it might have been an American consulting firm (Booz Allen Hamilton International) and not a Japanese firm since the study was based on data for American firms. The study of the actual modifications which would be necessary to carry through the project seem to have been done by USIMINAS' Department of Engineering and the Maintenance Division of the steel section.

The capacity increase achieved in this second stage was sufficient until the beginning of 1969. During that period the rapid increase in sinter production allied with other measures taken in the blast furnace section permitted a production of pig iron above 720.000 t.a. Within that context, the steel section studied the possibility of producing 850.000 t.a. The planning for that new stage required more in-depth studies that had been necessary for the previous two stages because a new increase in the charge would create operational difficulties not only in terms of reprojecting the installations, but also because of repercussions on various equipments in the flow of production as some had already exhausted their possibilities for capacity increases. One solution which was conceived was to take advantage of the increase in the effective volume of the converter which resulted from the wearing away of its refractory throughout its lifetime. This would involve increasing the tonnage of its charge as use gave it greater volume. In that way greater average tonnage per run could be obtained. After various studies, the Department of Production Control established the feasibility of such an approach and identified the major changes in auxiliary equipment which would be necessary. These included an increase in the capacity of the scrap charging equipment, the ingot casting equipment and the steel laddles; reinforcement of the converter's brakes; and a speed-up of the ingot casting cycle so that it could handle the steel produced under the new system without causing a problem of balance between the two cycles. It seems that the modifications which were necessary in the ingot casting equipment were such that it was not feasible to increase its capacity for the time being, so the plan was not workable in the short run.

All of these studies had been based on the utilization of a one channel oxygen lance, which was the conventional equipment. USIMINAS was able to overcome the impasse described above by adopting a three-channel oxygen lance. It seems that the idea and the guidance ø for this technical innovation came from Nippon Steel[1] with which USIMINAS had a general 10 year technical assistance contract. The use of the three holed lance made unnecessary the modifications in the ingot casting crane, the ingot casting cycle, and the a scrap charging equipment. The only modifications which were necessary with the introduction of the new lance in order to increase capacity to 850.000 t.a. were:

1) increase of tonnage per run fron 62 to 67 t.,
2) increase of the maximums oxygen charge from 900 Nm^3/h to 11.000 Nm^3/h average
3) reductions in the stop times,
4) scrap cannals of greater volume.

In addition to these changes four other factors were influencial in reaching the higher productivity levels: a) constant and gradual improvement in the efficiency of all personnel, which reduced operating times and operational loses; b) improvement in the system of cleanning the convertor, through a process developed by USIMINAS' own team; c) reduction in the time taken for the repair and exchange of damaged converters; and d) better preventive maintenance which permitted an increase in the index of operating time/calendar year from 65.2% in the first semmester of 1967 to 87% in the second half of 1969.

Unfortunately we do not know for sure how USIMINAS was able to increase production from 850.000 t.a. in 1969 to 950,000 tons in 1971 added. We do know that in November, 1969 they were

(1) Leuschner, Op. Cit., p.41

thinking in terms of increasing the production to 950.000 t.a. by : a) the modifications conceived for the original third phase which were not carried out when the new oxygen lance was introduced; b) increase in tonnage per run from 67 to 70 t. c) redimensioning the ingot molds; d) adopting special refractory bricks for the scrap and steel run sites, which would further reduce costs and time spent on those operations; e) introduction of a new system of inventory of spares to reduce costs and increase the speed of substitpion ; f) increase in the amount of oxygen injection from 11.000 to 12.500 Nm^3/h including an increase in the storage capacity for oxygen (as its production is continous while its use is discontinous); g) minimization of stops due to lack of pig iron by assuring that pig iron production is greater than demand and using any resulting excess for ingot molds; h) purchase of a communication system to improve the speed of communications i) improvements in calcination to increase production and quality and to reduce oxygen blowing time.

The increase from 950,000 to almost 1.200,000 in 1972 was achieved by an increase in the average number of runs per day from 42,9 in the first semester to 49,2 in the second. This was possible through the greater availability of oxygen (resulting from the installation an additional oxygen plant) and operational changes which made it feasible to operate the two converters simultaneously except when one was being relined.(1)

Although once again we have not been able to cover the whole period or to analyse the changes which have taken place in detail, the material collected provides several interesting insights it into what went on in the steel shop in terms of technical change. First, there was a period of familiarization with the equipment and basic operating conditions which took about three years until nominal capacity was achieved. Second, the increase in capacity from then until 1969 was

(1) The source of this information is the 1972 Annual Report pp 11-12. Usually a two converter operation only has one converter operating at a time. One converter is used while the second is relined. That USIMINAS was able to operate both simultaneously implies that it must have reduced maintenance time and or increased the life of the refractory by better control of the refining process.

achieved in three stages. The first two were much simpler that the third one originally conceived. The third one actually realized was based on an innovation imported from abroad. It seems, nevertheless, that apart from such special boosts which may be obtained by utilizing special technological "breaks" developed elsewhere, there was increasing difficulty in stretching capacity as successively higher levels were reached that they required more experience and more in depth studies. This suggests that there are saturation effects to the amount of capacity increasing technical change which can be squeezed out of given equipment. Third, the successful changes were the fruit of the coordination of various departments including operation, maintenance, and engineering, and the efficient utilization of external technical assistance. Fourth, the steel sector constantly received pressure to expand capacity to keep up with the capacity stretching occuring in the rest of the plant. This suggest that there are various push and pull pressures accross the different departments of the plant as they develop or are forced to develop their capacity stretching potential. and that these forces shift from one area to the next, for the proces is dynamic and the bottleneck is continually moving from one area to another. In relationship to the bottleneck it is interesting to notice that it also shifts within a sector, and that some changes in main equipment usually require numerous auxuliary changes which may or may not be feasible at a given time given the configuration of the existing equipment.[1]

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(1) This is a clear example of the type, of focusing mechanisms which N. Rosenberg is refering to in his article."The Direction of Technological Change: Inducement Mechanisms and Focusing Divises" Economic Development and Cultural Change: Vol. 18 nº 1 Part 1 (October 1969)

6.3.5. Rolling Sections

In the rolling section USIMINAS originally installed a slabbing mill with a capacity of 1.500.000 t.a. which was initially set up with the auxiliary ovens and cooling beds to handle 500,000 t.a.(1). Its capacity was to be increased by addition of more ovens and cooling beds as required by subsequent expansion. The mill, a Two High Reversible High Lift Slabbing Mill was supplied by SACK Ishikawajima and started operation in June 1963. After passing through the slabbing mills the plates went through a two High Reversible Broad Side Mill and through a Four High Reversible Plate Mill which entered into operation in July 1963. The semi-fininshed products made in this initial stage were sold to COSIPA and to Ferro and Aço of Vitoria which had excess finishing capacity while USIMINAS completed installing its hot and cold rolling mills which only entered into operation in 1965 thus completing the integration of the plant.

Our information on the technical changes which took place in section is limited to the following main details. Originally the plate mill served alternatively for the production of thic plates or for the preparation of plates for the hot strip mill. With the entrance of the new 4,100 mm plate mill, the old plate mill passed to be used exclusively to prepare the plates for the hot rolling mill. That change permitted the old semi-continous hot strip mill to became a continuous mill. The slabbing mill underwent several reforms including an increase in the power of its motors which permitted an increase in its capacity from 1.5 M.t.a. to 2.0 M.t.a for Phase II. In the case of the hot strip mill, production capacity is directly related to the auxiliary equipment, particularly the reheating ovens, and to the production program.

(1) The minimum efficient size for slabbing mills is around 1.500.000 t.a. so steel firms often install mills of that size and equip them to handle a smaller volume of production. As production expands, the auxiliary ovens and other equipment are added on until the capacity of the mill itself is fully utilized.

Successive production capacity increases were achieved in large part through the installation of more reheating ovens. The jump from 1.7 M.t.a. to 2.2 M.t.a is to be achieved by the addition of a fourth walking beam type reheating oven. For Phase II a remotorization and the installation of an automatic thickness control (AGC) similar to that installed in the 4 100 plate mill was programed, besides a new laminar type cooling system. In the cold strip mill, with the installation of the tandem cold mill the old mill was transformed into a skin pass. The doubling of the capacity of the tandem mill was programed for Phase II through various reforms including doubling the rolling speed. Another change, the switch to chloric acid from sulfuric acid in the pickling line is supposed to a occur sometime in 1979/80. Besides the various physical changes already noted a major change is the adoption of a production programming system linked to orders considerably increases efficiency and improves productivity and quality and should probably reduce costs.

Figure 6.15 gives a break down of total production by main product group which is graphed in figure 6.16. Notice that whereas the percentage of plates in production has fallen, that of hot and cold rolled coils has increased. Cold rolled products represent a more processed output which in general commands a higher price. It should also be noted that within the general products group USIMINAS has constantly sought to improve the quality and types of steel produced. This type of product diversifying technical change has been accomplished in part through a long term technical assistance contract which is discussed in section 7.6.

Figures 6.17-16.22 give the evolution of various yield parameters for some operations in the rolling section. Figure 6.17 traces the evolution of the yield in the transformation of slabs of killed steel to thick plates.(1) The yields increased

(1)Yields vary according to type of steel

Figure 6.15

EVOLUTION OF BREAK DOWN OF USIMINAS' PRODUCTION 1963-1977

Date \ Production	PLATES	%	Hot Rolled Sheets	%	Hot Rolled Coils	%	Cold Rolled Sheets	%	Cold Rolled Coils	%	Total
1963	19096,1		-	-	-	-	-	-	-	-	19096,1
1964	84214,2		-	-	-	-	-	-	-		84214,2
1965	139624,8	87,7	7137,1	4,5	12387,9	7,8	-	-	-	-	159149,8
1966	145100,4	48,3	53017,8	17,7	63378,3	21,1	35782,6	11,9	2972,0	1,0	300251,1
1967	145901,8	42,6	62907,3	18,4	61483,4	18,0	41011,8	12,0	31133,8	9,0	342437,5
1968	148353,5	36,0	86234,6	20,9	76617,0	18,6	67110,0	16,3	33680,1	8,2	411995,2
1969	208212,9	40,7	93372,7	18,2	99663,0	19,5	86944,6	17,0	23560,0	4,6	511753,2
1970	239647,5	39,6	94562,3	15,6	141798,0	23,4	99036,6	16,4	30252,3	5,0	605296,7
1971	261707,9	36,9	138832,7	19,6	145581,0	20,5	135898,7	19,1	28066,7	3,9	710087,0
1972	348778,1	38,8	174301,1	19,4	226796,5	25,2	109697,8	12,2	36637,5	4,4	898211,0
1973	339591,8	33,6	210266,7	20,8	290936,4	28,8	133550,6	13,2	35560,4	3,6	1009905,9
1974	333141,4	35,8	196262,4	21,1	188527,4	20,2	166276,0	17,8	47588,5	5,1	931795,7
1975	359390,5	27,8	247429,8	19,1	270990,8	20,9	195519,4	15,1	221234,3	17,1	1294564,8
1976	249520,5	15,3	300653,7	18,4	515878,3	31,6	227164,8	13,9	339399,1	20,8	1632616,4
1977	642099,3	28,8	299969,5	13,5	656947,0	29,4	236325,3	10,6	394848,1	17,7	2230189,2

Source: Information provided directly by firm.

Figure 6.16

EVOLUTION OF USIMINAS PRODUCTS 1963-1977

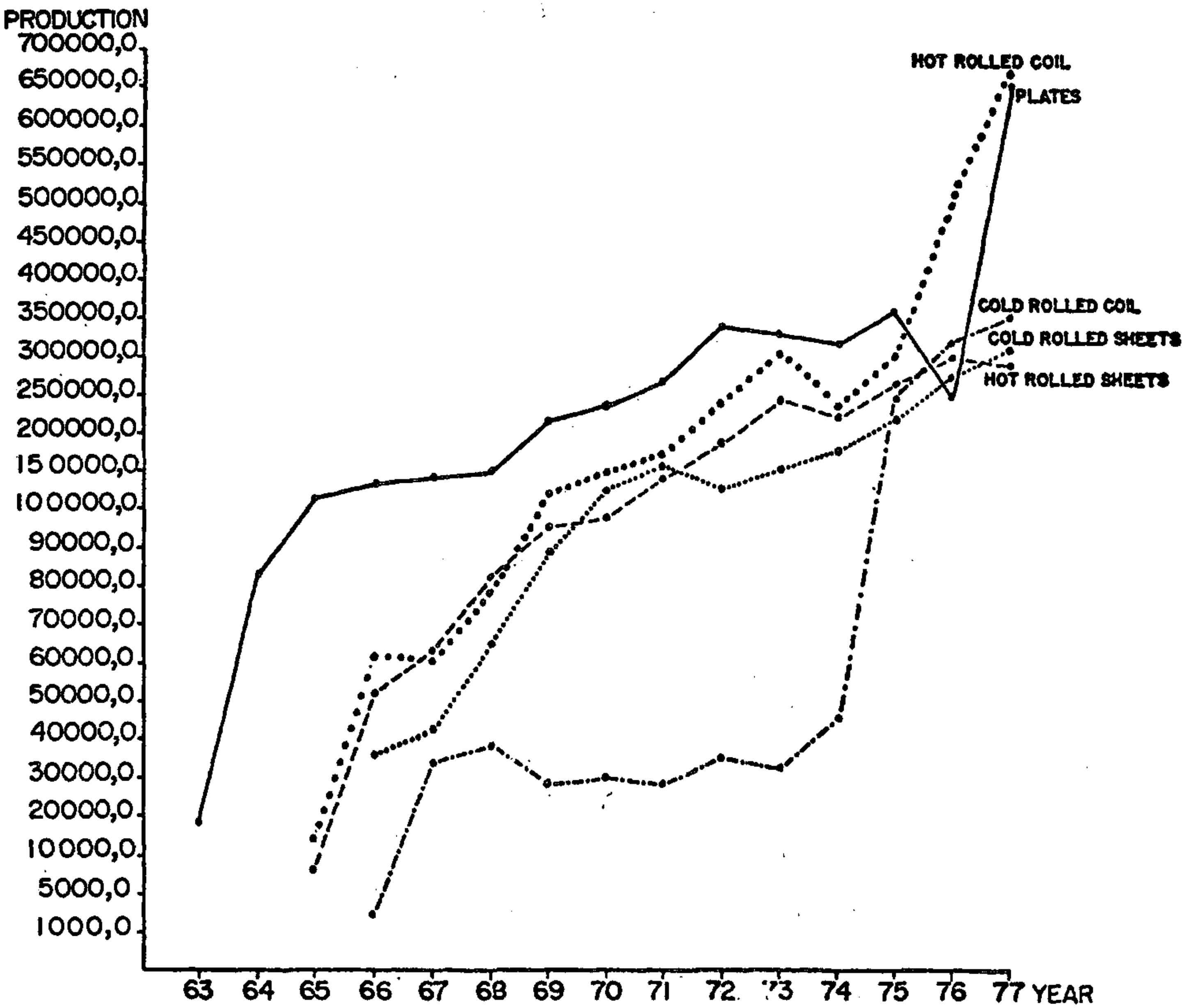
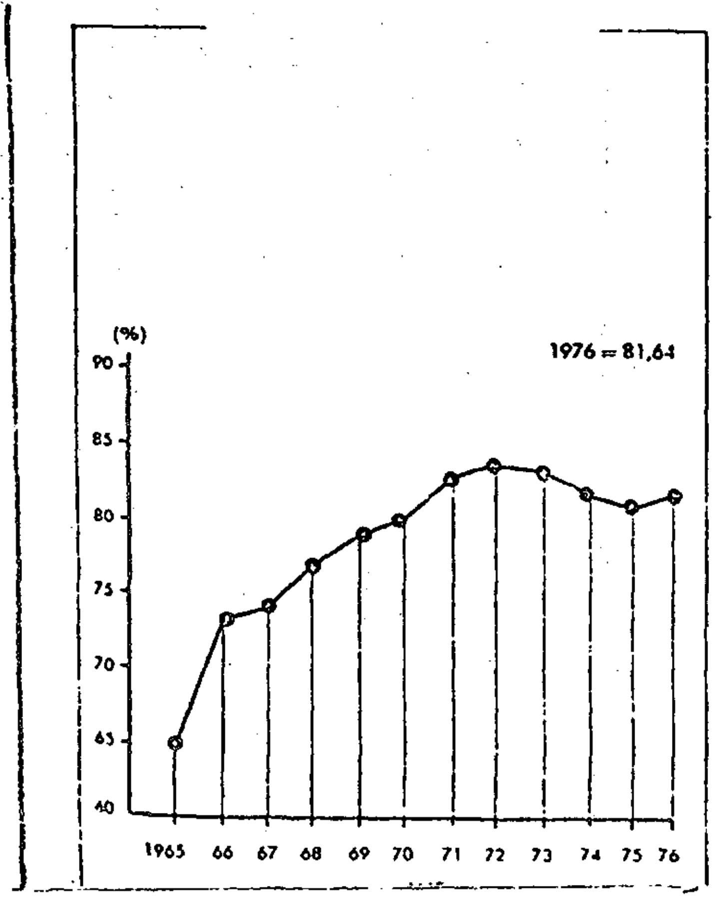
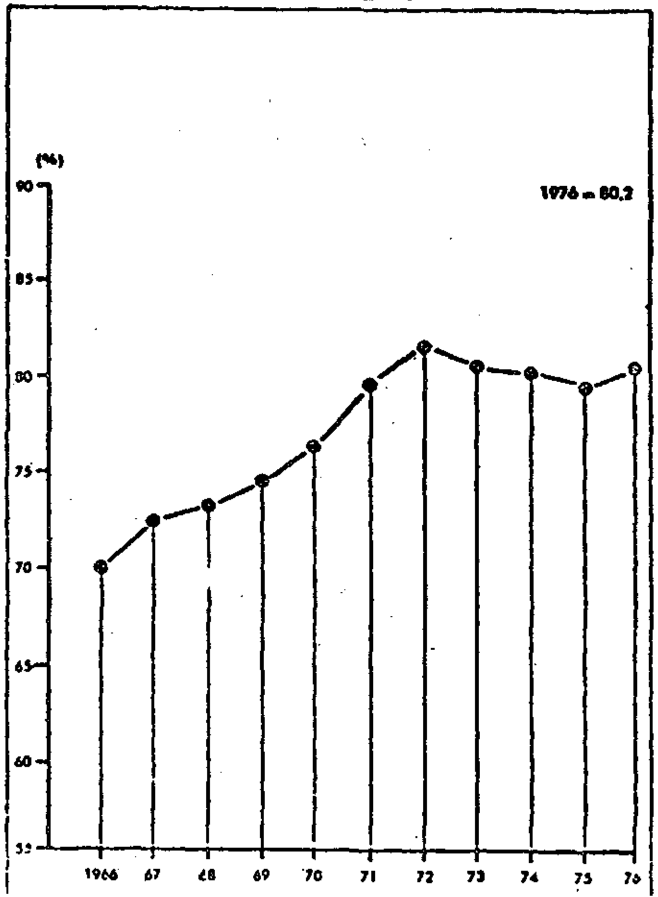


Figure 6.17. : Yield: Slabs/Ingots of Calmed Steel for Thick Plates



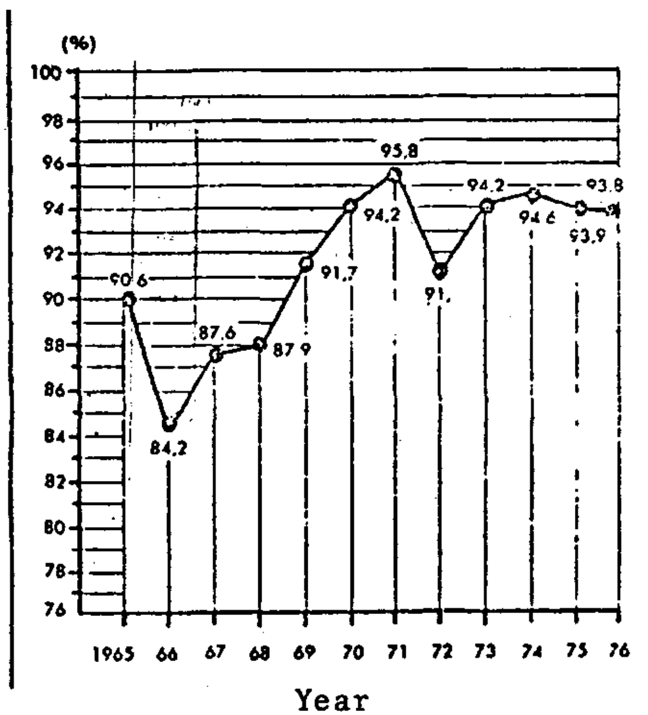
Source: Cota,"Alguns Aspectos..." pp.81-82

Figure 6.18: Yield of First Quality Thick Plates



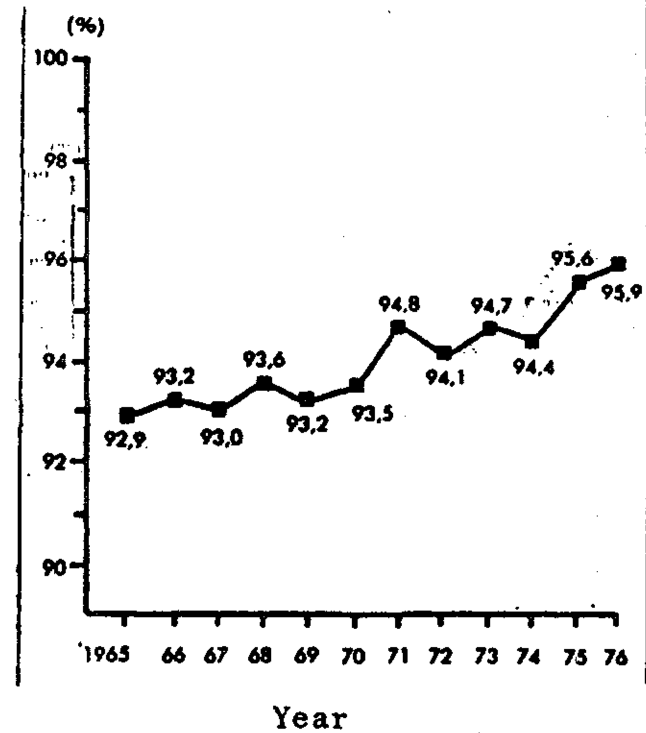
Source: Cota, "Alguns Aspectos..." pp.81-82

Figure 6.19: Yield of Inspection of Hot Rolled Sheets



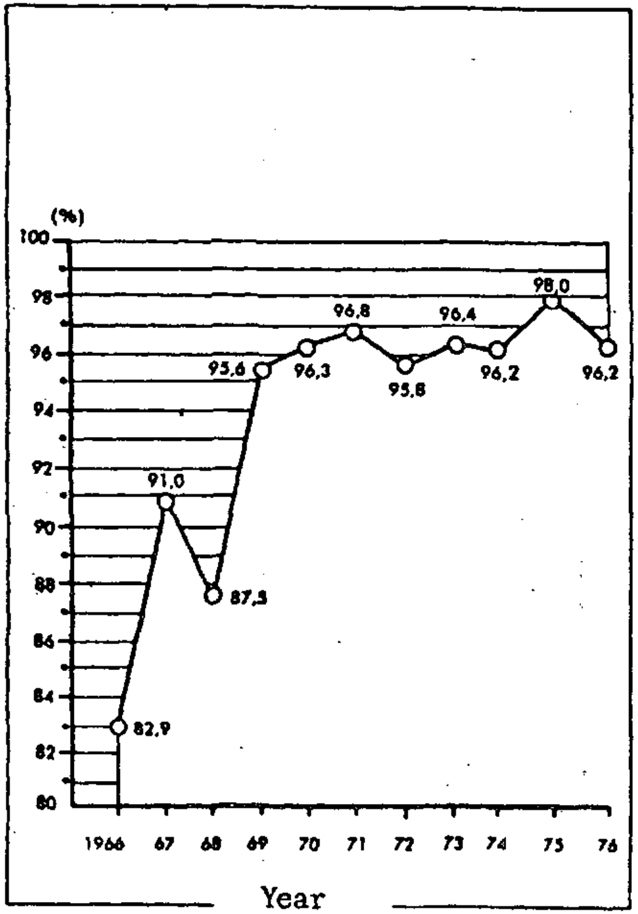
Source: Cota, "Alguns Aspectos..." pp.81-82

Figure 6.20: Yield: Cutting of Hot Rolled Sheet



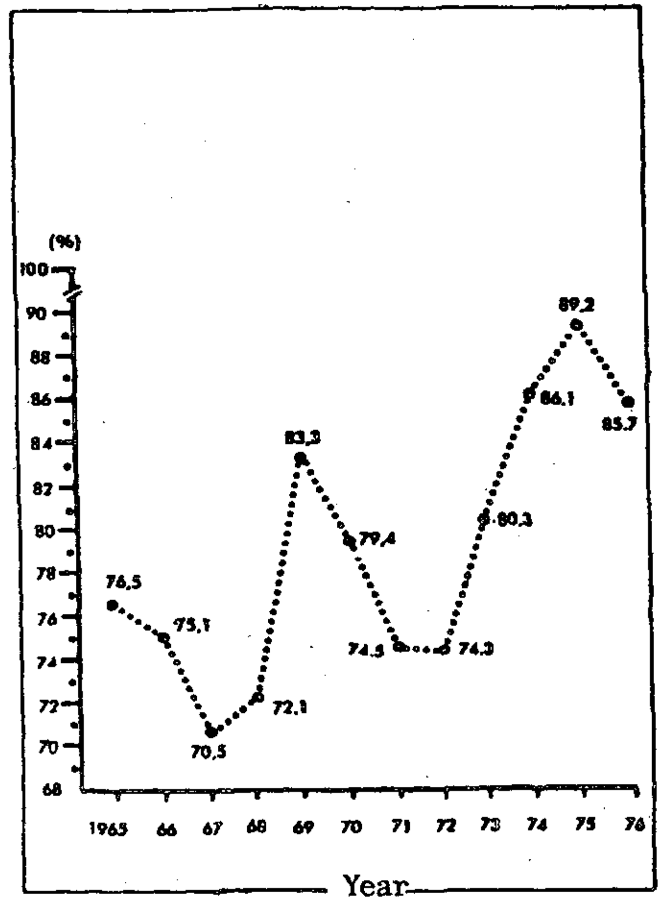
Source: Cota, "Alguns Aspectos..." pp.81-82

Figure 6.21: Yield of Inspection of Hot Roll Strip



Source: Cota, "Alguns Aspectos..." pp. 81-82.

Figure 6.22: Yield of First Quality Cold Sheet



Source: Cota, "Alguns Aspectos..." pp. 81-82 rapidly between 1965 and 1972 after which they suffered a small fall before leveling off. Figure 6.18 shows how the yield of first quality plates has evolved. Once again, there is a continous increase until 1972 after which there is a leveling off. A similar pattern is presented in figure 6.19 for the yield in the inspection of hot rolled coils.

Figure 6.20 shows that in the evolution of the yield from cutting hot strips into plates there has been a gradual improvement of about three percentage points[1]. Figures 6.21 and 6.22 on the yield of inspection of hot rolled sheets and first quality cold rolled sheets respectively show a somewhat more erratic performance although there is a clear upward trend particularly after initial operation.

In general then as can be seen by the series presented, there is evidence of significant improvement in the yield of various of the rolling operations.

6.3.6. Conclusion

Even though we have not been able to collect complete data on the techncial changes which have taken place with the original equipment, we have shown that considerable change has occurred. Although the main focus has been capacity stretching it is evident that technical change has also involved quality changes and cost reductions. It is also evident that particularly in the more raw material dominated sections such as sinterization and blast furnaces the bulk of the technical change has been with respect to control and preparation of raw materials and that in large part it has been the reaction of the firm to fluctuctions in the chemical and physical quality of those raw materials.

Our analysis has also shown that the changes which have occured have generally been gradual and evolutionary, that they have involved many fronts from control of raw materials to product and process control, that they involve not only changes in the raw materials, or in the adaptation of existing equipment or the utilization of auxiliary equipment, but also changes in organization and production flow and control methods.

It was also evident that equipment of a given vintage was able to take advantage of auxiliary technologies such as fuel injection and oxygen enrichment in the case of blast furnaces, and the three hole oxygen lance in the case of the steel shop. Although we did not have enough information to corroborate the impresion, it was suggested that despite these boosts given by the utilization of auxiliary technologies there may be decreasing improvement possibilities as the more obvious modifications are made. In a sense, there seems to be a limitation to how much can be done with a given equipment or a given layout. The possiblilites opened up by being able to change the lay-out, to ask for special features in new equiment in order to a better adapt it to local conditions and to the rest of the plant's structure and the advantage of having new technological advances built into it are the topic of the next section.

6.4. Technical Change Possible With Large Expansion

As was noted in chapter five starting in the early seventies USIMINAS entered into a phase of large capital intensive plant expansions. These expansions will elevate the plant's productive capacity to approximately three times what it was able to achieve with its original equipment and will make the plant's production about seven times its originally planned capacity.(1)

Although the products are still non-coated flats, their dimensions and quality grades have changed. The first two steps of the basis steelmaking technology still remain the same - coke based blast furnaces and LD steel shops - but the failicities have been considerably expanded. There are going to be four coke batteries rather than two, three sinter machines instead of one, three blast furnaces instead of two, the first steel shop received a third converter, and a whole new steel shop with two larger converters was added. A major change has been the adoption of continous casting for part of the production of the new steel shop, in addition to conventional ingot casting. There have been significant modifications in the rolling section. It now has continuous hot and cold rolling mills, as opposed to the old semi-continuous ones; an automatic scarfing machine rather than manual scarfing as before; new hot and cold skin passes to improve the quality of the hot and cold strip; the pickling process has been changed from a sulfuric acid base to a hydrocloric acid base; eletrolitic cleaning has been installed; and a new, large dimension plate mill has been added which has permitted USIMINAS to switch its plate production to the very marketable wide plate which it could not produce before. In addition a major adaptation has been to turn the old plate mill to the first part of a continous hot rolling line.

(1) In 1976 USIMINAS was the largest producer of non-coated flats in Brazil. It supplied 96% of the plates consumed in the naval industry, 53% of the Brazilian plates consumed in the automobile industry, 64% of those used by the railroad industry, 70% of those in the heavy capital goods industry and 40% of those, in the electric-electronic industry. It is also Brazil's leader in steel exports.

It should be noted that by and large all the changes mentioned above with the exceptions of the change in the pickling process and electrolitic cleaning involved either the adoption of larger scale units (coke batteries with twice the capacity as original ones, steel shop with converters almost three times as large as those in original plant, sinter machine with twice the area of the old one, blast furnace with output three times that of each of the old ones, new wide plate mill) or an expansion of the product run (switch from semi-continous to continous mills, use of old plate mill as first step in hot strip mill line, automatic scarfing).

In part this reflects the general tendency discussed in chapter four for many new technological developments to be embodied in capital equipment of ever increasing scale.

It was our original intention to compare the types of savings which could be achieved by the adoption of such larger scale and newer vintage equipment units . However it was not possible to obtain cost data disaggregated by equipment units. Also significant distortions in the cost structures derriving from the energy crisis have coincided with the entrance of the new equipment units making more difficult any such analysis.

In particular it would have been interesting to use the historical data to calculate how much a given increase in capacity with the old equipment had cost as compared to a similar increase through the installation of newer vintage units. This type of analysis would have very interesting implications for rennovation versus modernization strategies.

Abstracting for a moment from differences in variable operating costs a very rough aggregate calculation could be as follows. The original plant was estimated to have cost U.S.$ 261 millions for a capacity of 500,000 tons. The expansion from 1,400,000 2,400,000 was estimated to cost U.S$ 961 millions, and the expansion from 2.4 M.t.a. to 3.5 M.t.a is expected to cost U.S.$ 1061 millions this gives the following average cost per ton:

original	261/500	U.S.$ 522/ton
1.2 to 2.4	961/1200	U.S.$ 800/ton
2.4 to 3.5	1061/1100	U.S.$ 964/ton

This calculation has not been adjusted for inflation which would tend to make the real cost difference less favorable or even reverse the advantage of the original investment. However it most be remmembered that the capacity of the original equipment was raised to close to 1.2 M.t.a. Assuming for the sake of argument that the cost of achieving that was the $ 30 millions dollars invested in technology contracts and the $ 10 millions invested in training (not all those sums should be counted as costs because the expenses were more heavily concentrated in the post 1972 period, but on the other hand probably other expenses were incurred) the marginal cost of the expansion from 500,000 tons to 1.2 M.t was just $ 57 dollars. This would compare very favorably with the capital intensive expansion even after taking account of an inflation adjustment and granting a 50% capital subsidy.

This however has also abstracted from among other things the problem of saturation effects to rennovation or capacity stretching type strategies which is related to the issue of what is the optimum amount of such stretching.

In practice such issues of scale are likely to be very important and it is precisely there that new vintage equipment may have the advantage. Nevertheless it should then be kept in mind that the new vintage type strategies may be constrained by the rate of growth of the market which is what may determine what type of scale expansion is possible. In the Brazilian case the size of the market and its rate of growth are more likely to permit such larger scale expansions than in most other Latin American countries where the market and perhaps also its rate of growth are likely to be smaller.

Returning to the USIMINAS case an interesting aspect about the technological possibilities opened up by expansions has to do with the possibility of embodying the technical experience learned from operating the original equipment into the new equipment through the specifications for it. This was done in the case of the new sinter machine.

In order to focus on this aspect the rest of the section will develop what kinds of activities which are involves in major equipment purchases by citing the examples of the third blast furnace and the second steel shop.

6.4.1. The Purchase of Blast Furnace nº 3(1)

The background to the installation of the third blast furnace was as follows. In the original expansion plan to produce 1.4 M.t.a. the the first part of the expansion was to be a

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(1) The information for this section is based on USIMINAS, Superintendencia de Engenharia de Projetos "Alto Forno 3: Desenvolvimento Projeto e Construção" USIMINAS REVISTA Ano 5, nº 10 (December,1974) pp. 54-78.

reform of the two original blast furnaces. These included an increase in the internal volume of blast furnace nº 1 from 891 m^3 to 957 m^3 by modififing the refractory lining; and reconstruction of blast furnace nº 2, in order to increase its internal volume to 1090 m^3 'which would involve not only a change in the refractory but also in a modification of the carcass and substition of the blowers by some of greater capacity. The first reform of blast furnace nº 1 was carried out as planned. The reform of blast furnace nº 2 was to have been finished in February 1974 in order to satisfy the goal of 1.4 M.t.a expansion plan. The cost, including changing the regenerators was estimated at nine million U.S. dollars. A paralyzation of its production for a minumum of five months involving a production loss of close to 19 million U.S. dollars would also be necessary. In view of these high costs, plus the speedup of the expansion plans, USIMINAS decided to carry out the reform of the second blast furnace within the same bases adoped for the first - a simple change of the refractory lining without a modification in the carcass and to build more capacity into the blast furnace which was to be installed for the 2.4 M.t.a phase. This new blast furnace was to have a internal volume large enough to permit it to produce enough pig iron in conjunction with the other two to satisfy the needs of the 3.5 M.t.a plan. Furthermore the new blast furnace was to be ready for production when blast furnace nº 2 was stopped for reform.

Studies on the dimensions of blast furnace nº 3 began to be done as far back as February 1971 in the operation section of the plant with the cooperation of a study team from Nippon Steel. As a result of the preliminary studies it was considered most convenient to construct a new blast furnace with an internal volume of approximately 2.500 m^3 Based on the productivity usually reached in such large furnaces with the use of top pressure, it was estimated that a value 2.2 $t/day/m^3$ could be reached by using good preparation of the raw materials and good quality coke. Based on the experience of USIMINAS it was also estimated that coke consumption could be in the order of 520 kg/t with up to 90 kg of fuel oil injection. The plan which emerged was to:1) adopt the most advanced techniques currently used in modern steel plants, 2) consider specifications such that auxiliary equipment could be mecanized and automatized, 3) adopt new techniques recently employed in the tapping and in the structure of the furnace, 4) consider cowper type regenerators for a maximum blast temperature of 1150°C and 5)provide means of setting up a system for computer control which could be installed in the future without major modifications in the equipment.

The equipment for the blast furnace was dissagregated into nine basic packages(1) and international bids were called for as required under the conditions of the IBRD which was lending some money for the expansion program. An average of 37 bids were received per equipment package, and an average of 11 were found to be prequalified based on the qualification criteria USIMINAS had worked out with Nippon Steel(2) Competing suppliers were invited to meetings at USIMINAS where the specifications and other details for the project were explained. To give an idea of what this involved it can be noted for the blast furnace package alone the meetings required 51 man/days of USIMINAS' (Superintendency of Project Engineering) and 35 man/days of Nippon Steel advisors to answer questions formulated by 32 man/days of questions from the competing suppliers. The evaluation of the bids for that package required approximately 700 man/days from the Superintendency of Engineering, and 350 man/days from Nippon Steel. Ishikawajima Harima Heavy industries was selected the winner as a result of a considera-

(1) The packages, their distribution as a percent of costs and their nationalization index (in parenthesis) were: blast furnace and auxiliary equipment, 45.0% (29.8); refractory (two packages):18.1%(24.9) blowers, 8.4% (0); water recirculation system, 7.7%(0); furnaces for the blowers, 13.1% (32.8), torpedo car 6.6%(100); cranes 1.1% (0); and electric distribution system on which there was no specific cost data but is estimated to have cost about 2.2% and to have been all imported. The total cost of the equipment was approximately 32.5 million dollars of which 28.8% was bought in Brazil.

(2) In the case of the blast furnace, the prequalification requirements were having experience in projecting or supplying at least two blast furnaces with an internal diameter of more than 10 meters. Eight firms representing 5 countries met the requirements.

tion of both the technical and financial aspects. Close to 110 meetings were made with Ishikawajima to discuss the technical details which required an additional 260 man/days from USIMINAS, 330 from Nippon Steel and 550 from Ishikawajima and its subcontractors.

The principal projects of the equipment were executed by the equipment suppliers. The remaining projects (foundations, lighting electricity, finishing of the control room) which required over 70,000 manhours were projected by Brazilian firms with the coordination and orientation of the Superintendency of Project Engineering. Civil works were carried out by Brazilian firms and required almost 6.7. million man hours. The basic project engineering for the units however, was done by the corresponding equipment suppliers. Detail engineering was done by Montreal Engenharia, a local Brazilian firm. Civil works and mounting of the equipment were done under the supervision of the Superintendency of Construction with technical support from the Superintendency of Projects. Various local construction firms were subcontracted for the project. A local Brazilian engineering firm was contracted for the mounting of equipment and setting of the refractories. It received 72,00 manhous of technical assitance from Sankyo of Brazil and the supervision of 60 technicians from the various equipment suppliers who were contracted by USIMINAS to provide technical assistance during the construction. Nearly 6 9 million manhours were required for mounting the blast furnace and its auxiliary systems and 1.5 million for its refractory. For the orientation and coordination of the mounting USIMINAS received nearly 17,600 manhours of assistance from Nippon Steel and 88,000 manhours of supervisory assistance from the various equipment suppliers.

The total costs of blast furnace nº3[1], excluding administrative costs and the costs of the national and imported technical services was approximately 66.5 million dollars, distributed as follows: fabrication of equipment and structures, 40.9%; supply of refractory, 9.5%; civil works, 16.9%; mounting 20.9%; setting of refractory, 3.9%; various others, 8.0%. Of this total 64.4% was spent in Brazil.

(1) Based on study done by the Supervision of the Budget of in October, 1974.

6.4.2. The Purchase Steel Shop nº 2[1]

A new steel shop was the other main unit in the second expansion plan. This plan foresaw the adoption of a continous casting line for the second steel shop if technical studies showed that to be feasible. The main factors which determine the feasibility of a continous casting facility are the product line and the market. Since USIMINAS was a flat products producer, continous casting would be used for the production of slabs. As the Brazilian industrial sector (the main consuming market) was going through a phase of rapid expansion, and since considerable technological improvements were still taking place in continous casting, USIMINAS opted for a flexible line. On the one hand it was to cover not only all the types of steels manufactured by USIMINAS but all those which could be produced by continous casting. On the other, it was to attend to a very wide range of dimensions including the new 4,100 mm plate mill which was also included in this expansion plan.

Specifically the 2.4 M.t.a. plan projected one million tons increase in steel capacity which was to be filled by the new steel shop. The project designers decided to use two 160 ton. converters to supply the one million ton increase in view of the future expansion plans and the fact that small converters would not be as economic and would not be very adequate to supply continous casting of slabs of large dimensions. The new steel shop was projected to supply both conventional ingot casting and continous casting. Conventional casting capacity was projected for up to 0.4 M.t.a. in order to supply the existing slabbing mill in conjunction with the old steel shop. The capacity of the continous casting was thus established by subtraction to run from 0.6 to 1.0 M.t.a. Studies based on the correlations between types of steel to be

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(1) Information for this section is base on USIMINAS, Superintendencia Geral de Engenharia da USIMINAS. "Aciaria nº2, Desenvolvimento, Projeto e Construção" USIMINAS REVISTA, Ano 6, nº 12 (Setember 1975) pp. 36-54.

produced, dimensions of the slabs, cycle time for converter operation stops for preventive maintenance, stops for modifications of the dimension of the slabs, etc, determined the need for two continous casting machines of two channels each. A third was to be added in the next expansion.

The equipment for the steel shop including the two casters was divided into eight packages(1), which were opened to international bidding(2) as required under the IBRD contract. An average of 36 suppliers responded per package and an average of 12 were found to meet the prequalification criteria.

As in the case of the blast furnace the projects for the equiment were done by the respective suppliers. The civil construction. totalling about 5.8 million man/hours was done by local Brazilian firms. The foundation for the steel shop, the continous casters and the water system, however were projected and detailed by the respective equipment manufactures. The foundation work itself was controlled by the Superintendency of Construction with technical assistance from the General Superintendency of Enginneering and follow up was done through a PERT CPM system. Mounting of the continous casters was done by Montreal Engenharia (the same local Brazilian engineering firm which did the mounting of the blast furnace) under the control of the Superintendency of Construction. To better accompany and control the work, a special steel group was created with members drawn from engineers of all sectors related to the steel shop. Nippon Steel provided almost eleven thousand man/hours of supervisory assistance for the mounting work, and the equipment suppliers provided another 106 thousand man/hours of supervisory assistance in mounting the various equipment.

(1) The packages, their distribution as a percent of equipment costs and their nationalization index (in parenthesis) were: steel shop 42.5% (26); laddles, 1.2% (73); continous casters, 36.4% (0); water system for continous casters 2.7% (0); press for refractory, 1.3% (0); heavy cranes, 4.0% (0); light cranes, 11.2%(100); spectrometer with computer, 0.8% (0). The total equipment cost was 59.8 million dollars of which 23% were spent in Brazil.

(2) For the steel shop itself 12 firms representing 7 different countries met the qualification requirements; for the continous casting equipment 8 firms representing 5 countries met the prequalification requirements.

The total cost of the equipment, civil contruction and mounting of the second steel shop, including continous casting but excluding administration and supervisory costs, was U.S. $ 110.2 million dollars. This was distributed as follows: equipment and structures, 63.3%; mounting, 22.5%; civil works, 14.2%. Of the total 58.2 % was spent in Brazil.

6.4.3. Conclusion

From these relatively detailed descriptions several interesting points can be learned. First of all they show the relatively long planning horizon which is required. Notice that plans were already underway in 1971 for equipment which did not enter into operation until December 1974 (blast furnace) and September, 1975 (steel shop.) Secondly attention should be drawn to how the specifications of the equipment very strongly depend on interrelationship whith other existing equipment not only in timing when it should enter but it what capacity it should have. Third notice the kind of preparations necessary in terms of elaborating and explaining the specifications to the potential suppliers. Notice too that the basic equipment was dissagregated into various packages, each of which was opened up to international competion. It is not clear to what extent this would have been done if it were not a IBRD requirement, but in any event it is probable that if it resulted in better deals it was an proceedure which the firm would have learned to use for future plans.

The descriptions also serve to show the incredible amount of planning and coordination of involved in the set-up and mounting of the equipment. This requires not only competent technical capacity from supervisory units internal to the firm, but from the equipment suppliers and subcontracted parties. In this intermediate phase, USIMINAS required technological assistance in planning, basic conception, selection of suppliers, mounting and inspecting the equipment, but this served as an investment in experience such that USIMINAS was able to do all this on its own for the third expansion plant.

Although somewhat off the main topic, it is also possible to see growing participation of Brazilian firms a vis a vis foreign firms not only is some of the engineering (concentrated in detail engineering) but also in terms of equipment supply. This is a long way from the situation at the time the firm was first constructed when nearly all the equipment and engineering had to come from abroad.(1) Clearly the participation of Brazilian firms in these kind of projects under close technical supervision and advice from USIMINAS, its advisor, and the equipment suppliers provides an important learning experience which helps to further develop local engineering and capital equipment manufacturing capacities and prepare them for even greater particaption in future projects. This is a non-negligeable technological externality which should be taken into account along with the firm's other contributions in terms of human capital training and the flow of human resources developed inside the firm to other firms.(2)

From the specific perspective of the relationship between expansion and technology very interesting interrelationships, are also implied.

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(1) See figure 7.5. for aquick graphical survey of Brazilian steel project engineering.

(2) For example Manoel Moacelio de Aguiar Mendes, formerly the Superintendent of Project Engineering left USIMINAS to become president of AÇOMINAS; Luiz Verano, formerly General Superintendent became president of USIMEC; USIMEC itself is such as externality as it was conceived by USIMINAS and was initially staffed with USIMINAS personnel.

Notice the tremendous amount of negotiation which is involved not only in selecting the equipment, but in dealing whith the chosen suppliers. This would seem to be a critical point because it is through the original specifications and subsequent negotiations and meetings (110 for the blast furnace, for example) that the firm can call for specific technical details in the equipment and ask for adaptations and modifications of the supplier's basic design for better performance in the local conditions and in relation to better integration with the plant's existing equipment and processes.

We would have liked to have had more specific details on the specifications asked for, the modifications made in the basic equipment, and at whose initiative (manufacturer, USIMINAS or advisor) they were made, in order to trace the contribution of each of the three parties to the adaptation to local conditions. Although we could not get this kind of detail it is obvious that in the give and take over specifications[(1)] there were important contributions not only from general advances in the technological frontier which may have already been built into the basic equipment model, but also from the suppliers, the firm and the advisors in terms of specific features added to better adapt it to operating conditions in general and to specific local conditions in particular.

It is worth remembering, for example, that since USIMINAS planned its first blast furnace the frontier evolved in terms of larger size blast furnace, oxygen injection, continous charging, and increased automatization of control. All of these technological features plus others which were available when the first furnaces were planned but

(1) An interesting point according to a high placed official within the company is that there was a problem in specifying the details of the equipment packages for the bids too finely. Since this was done with the help of the Japanese it sometimes turned out that the specifications were such that only the Japanese could meet them. The lesson learned was that equipment packages should he less rigorously specified before the bids and that there should be more negotiation with the winner to work out the details.

not then adopted, were built into the new blast furnace. Also there is no doubt that all of the operational experience under Brazilian con ditons developed by USIMINAS with more than 10 years of work with its original bast furnaces also were incorporated into some of the specific features asked for in the new blast furnace. With respect to automation of control of the blast furnace there is an interesting aspect which shows USIMINAS' cautious step by step strategy allied to provisons for the future. The blast furnace was built with all the sensors and specifications necessary for completely automatic control by computer. This automatic computer control was not adopted initially because of the lack of experience in computer control of such a large furnace. The strategy adopted for computer automatization is to proceed through three steps as operational experience is gained. Phase one consists off-line calculation of the charge and on-line calculation of the flame temperature, monitoring and execution of monthly reports. Phase two is to develop guidelines for the operation of the regenerators with off-line calculation of the volume of pig iron and slag accumulation in the crucible. Phase three is for direct closed circuit computer process control of the furnace and to hook up the process computer with the integrated computer information system which is being developed for the whole plant.

An interesting note on the interrelationship between equipment supplier and a firms operating experience is that according to a well informed source , the third blast furnace is supposed to suffer from some project deffects which are due to a problem between ISHIKAWA-JIMA and Nippon Steel. Apparently, although ISHIKAWAJIMA built several furnaces for Nippon Steel, the latter was unwilling to give it detailed information on their operational performance so ISHIKAWAJIMA has not been able to correct some problems. The newer blast furnaces more recently installed at CSN and COSIPA reportedly do not have these problems because they were supplied by Nippon Steel.

In short although we have not been able to get as much detail as we would have liked or to get more specific information on the planning and implementation of phase III, which is being done by USIMINAS itself, we believe we have drawn attention to the importance of engineering and technical change in terms of the possibilities opened up by expansion plans . Theses changes involve not only being able to get new units which embody more advanced technological developments (such as large size blast furnace with automatic charging and computer control) or changes in the process (adoption of continous casting) but also innumerous technical details built into the specification of theequipment and to the plant layout. This is an area where the operational experience and technical knowledge acquired by the firm over time can have important payoffs. The very choice of techniques and specifications of details require a well developed engineering and information gathering structures within the firm. As will be shown in the next chapter these have been very much developed withing USIMINAS and it is the growth of this technological infrastructure for the development of operational improvements and expansion plans which has made possible its impresive technological advances.

6.5. Costs, expansions, and the Energy Crisis

The distribution of relative cost shares of various imputs in the various production sectors of USIMINAS is given in figure 6.23. The costs are based on real costs for the first semmester of 1978, but they do not include depreciation or expenses with the head and regional offices.

The figure shows the importance of raw material costs in the overall cost structure They always account for more than 85% of the costs whereas labor never accounts for more than 6%. If the share of raw materials in the cost of producing steel were to be broken down into its components the share of labor would increase somewhat while that of raw materials would fall, but it is clear that the bulk of the costs would still be represented by raw materials.

The very large share of materials cost as well as the effects of various qualities of such materials on the productivity of the other factors is why so much of the technical change in the sinter and blast furnace section was related to the selection, preparation and control of material imputs.

Figure 6.24 shows the evolution of a deflated index of standard costs for each of the four products since 1969.(1)

The most striking feature of the indexes is the dramatic rise over the period 1974-1976. Although we have not been

(1) The actual cost figures were deflated using the price indexes for steel and derrived products supplied by the Fundação Getúlio Vargas.

Figure 6.23

RELATIVE SHARE OF VARIOUS IMPUTS IN PRODUCTION COSTS

Products / Imputs	COKE	SINTER	PIG IRON	STEEL
Raw materials	94.82	85.29	87.21	88.16
Direct Labor	0.40	0.38	0.25	0.25
Indirect Labor	0.49	0.46	0.30	0.29
Repairs and Maintenance	3.38	6.22	7.91	3.27
Fuels	(4.02)	1.34	(4.85)	(0.26)
Energy and Transport	0.70	3.48	5.77	3.68
Supplements to Operation	0.06	0.09	1.13	2.95
Administration of Plant	4.15	2.74	2.28	1.66
TOTAL	100.00	100.00	100.00	100.00

NOTES: 1) Shares were based on actual costs in 1978, which are supposed to be historically representative.

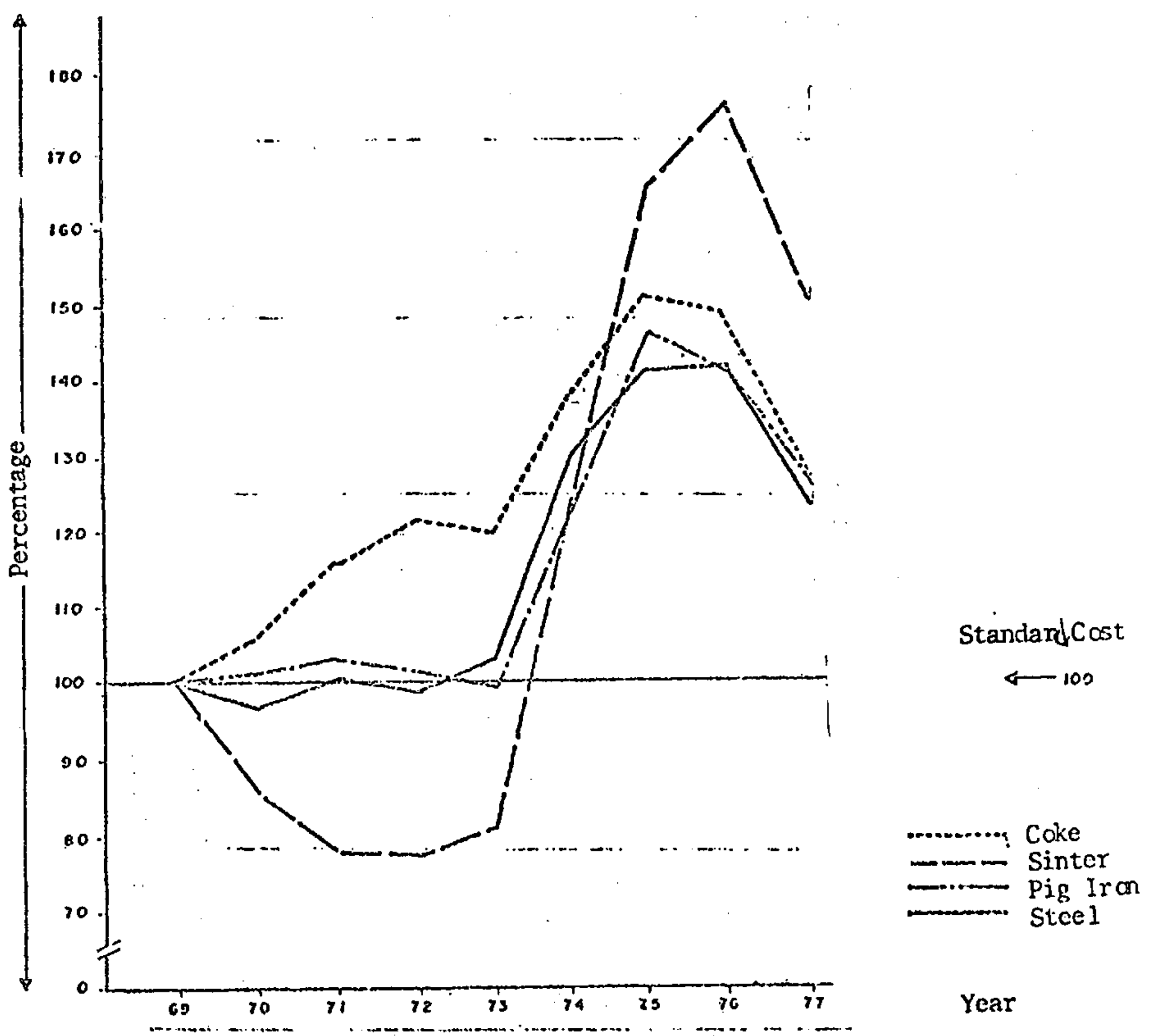
2) Depreciation and expenses with head and regional offices were not included

3) Parenthesis indicate a credit

SOURCE: Information supplied directly by firm.

FIGURE 6.24:

RELATIVE COST OF COKE, SINTER, PIG IRON AND STEEL
(Deflated Values) (Bas Year, 1969)



Source: Information supplied directly by firm.

able to obtain appropriate imput price series it seems that to large extent cost increased were due to the rise in the cost of raw meterials, particularly of coal which has a consequence of the 1973 energy crisis. As shown in figure 6.25 the price of coal approximately quadrapled as a reuslt of the energy crisis.

It is particularly striking to follow the evolution of the cost of sinter. Its costs had fallen about 20% between 1969 and 1971 probably in close connection with the more rigourous control of burning and ignition described in section 6.3.1, and the sharp rise of productivity per area of machine (figure 6.7.). Although its costs remained more or less constant between 1971 and 1973 they increased over 100% from the latter year to 1976. As can be seen in figure 6.24 during this period which also coincides with the entrace into operation of the new sinter machine, the productivity of the old sinter machine fell almost 100% in terms of output per square meter of area, and the new machine did not have as high a level of productivy as the old machine reached at its peak. It has not been possible to separate out the effects of the expansion from those of the crisis on such reduced performances, but it seems that both played an important part.

In the case of pig iron as well as steel the indexes show that the costs were maintained more or less constant between 1969 and 1973 after which they both rose in a very similar manner. The rise in the price of steel is very much a reflection

Figure 6.25

AVERAGE PRICE OF COKING COAL AND PERCENTAGE OF NATIONAL COAL USED BY BRAZILIAN STEEL INDUSTRY 1965-1976

	Average Price of Coal (1) US $/Ton	% Nacional Coal Used in Brazilian Steel Industry
1965	15.71	36
1966	15.56	30
1967	15.88	33
1968	15.99	33
1969	16.69	32
1970	21.32	30
1971	21.36	30
1972	21.97	32
1973	25.64	31
1974	50.99	40
1975	56.16	26
1976	59.12	28

(1) Average of prices in USA, Australia, Canada, USSR, Poland and South America

Source: Appendix III

of the rise in the price of the other products since directly or indirectly they are its material imputs.

The rise in the cost of pig iron can be in large part attributed to the rise in the price of imported coal and the need to use a greater proportion of poorer quality national coal which reached a high of 40% in 1974.(1) Notice that as a result of the poorer quality coke the output of blast furnace one suffers a sharp drop related to a fall in its productivity rather than to its operating index. (see figure 6.11).

The energy crisis lead the firm to orient research towards the reduction of energy consumption. One of the more impressive results of such a research effort was the development of a project to use coke oven cases for a Midrex direct reduction process. This would enable USIMINAS to sare 20% of the fuel in the blast furnace section and to increase steel production 20% with the same equipment originally foreseen for the 3.5 M.t.a. phase(2)

As a result of various energy conservation efforts involving several projects, USIMINAS achieved a reduction of 10% in its(3) overall energy consumption in 1977 as compared to 1976 even though its output increased 16% over the same period.

(1) For more details see Appendix III

(2) This project has not yet been implemented but Midrex has worked out a contract with USIMINAS whereby it will pay USIMINAS a royalty every time thee process is used.

(3) 1977- 5,561 Giga Calories/t.G.1

1976- 6,176 Giga Calories/t.G.1
Source information provided directly by firm.

CHAPTER SEVEN

7. ADMINISTRATIVE AND ORGANIZATIONAL CHANGES

What was analyzed in the previous chapter is just one aspect of technical change - the changes in machines, operating methods and physical indexes. The other part of the process of technical change is the human element behind the changes, its training and development, and the evolution of the administrative and organizational infrastructure within which such change is made possible. This chapter highlights some of these topics including an important administrative reform carried out in 1966, the implantation of a standard cost system and the technological support structure it required, the concept of a technological prism, organizational changes related to the expansion plans, investment in human capital, and technology contracts.

7.1. The Administrative Reform of 1966

As was explained in chapter three, initially operational responsibility for the firm was in the hands of the Japanese partners. They were in change of setting up the administrative structure and the various operating norms as well as of training the Brazilian team.

In general the firm rapidly attained satisfactory technical operational indexes. However as early as 1964[(1)] there was

(1) Information from a 1964 report to the Board of Directors "Considerations on the Present Operating Conditions of The Intendente Camara Works".

a feeling that the company had some problems in its administrative area. In part they derrived from the difficulty of transplanting a foreign administrative structure developed for a large established Japanese plant to a smaller plant getting started in a different socio-economic and cultural setting where there was less experienced personnel and a low professional level among workers in general.(1) There was also concern that the Brazilians were just being trained in the technological area and not for the administrative part, and that as a result their contributions for the improvement of the administrative conditions was very small. It was recommended that 1) there be an increase in the professionalization of the various key positions through training and intensive courses and through the admission of more qualified persons; 2) the Japanese be given even greater authority in the technological area but also increasing that of the Brazilians in the administrative areas so that both groups participated in the administration of the plant; 3) the responsibility of the various positions be defined more clearly; and 4) a specialized consulting service outside the firm be hired to study and propose a new administrative structure for the plant.

As a result in 1964 USIMINAS decided to hire the American consulting firm Booz Allen Hamilton International to study the company and to suggest a general administrative and personnel restructuring(2) of the firm. The study was done in 1965.

(1)Among the problems resulting from this situation were low worker efficiency, excess number of employees, difficult labor relations; lack of adequate raw material stocks; inadequate accounting, cost control, or budgeting; poor analisis, control, and maintenance services; precarious transport and product expedition services; and errors in the emission of documents.

(2)According to a various Brazilian officials in the firm, one of the reasons for the overstaffing in the plant was that the Japanese wanted to be sure that enough workers would be trained so that the best could be chosen to insure that each unit of their equipment reached record operational and production indexes.

Parenthetically it should be noted that in terms of participation in the capital stock. the Japanese share which had started at 40% and was maintained at that level through the first capital expansion in 1962 fell to 21.5% when capital was again expanded in 1965. In the various expansions since then it has been maintained at slighty less than 19%, as can be seen in figure 7.1[3] Notice too that in USIMINAS the largest shareholder has always been the Government (counting direct ownership and indirect ownership through its organs such as the Banco Nacional de Desenvolvimento, the State Government and CSN.) Recently Government control has been centralized in SIDERBRAS a Government holding company for all of the stock it owns in the Brazilian steel companies.

In 1966 the Japanese turned over operational control of the company to the Brazilians. The relationship between the fall of the Japanese share in the company and the acquisition of operational control by the Brazilians a year later is not clear.[1] As far as we have been able to ascertain the switch as made by Japanese initiative as they had finished the star-up of the plant and completed the period of free technical assistance.[2]

In any event the recommendations of the BAHINT study started to be implemented in 1966. Among the main reforms

(1) It should be remembered that representation on the board of Directors was supposed to be in proportion to the ownership of stock. As a result of the capital expansion five directors were chosen by the Brazilians and only one by the Japanese.

(2) Technical assistance was provided free of charge until one year after start-up. As the last units entered into operation in 1965 the assistance ended in 1966. After this a 10 year general assistance contract was signed between USIMINAS and Nippon Steel. It shall be discussed in section 7.6..

(3) In the second half of the sixties various memorandums of understanding were negotiated between the Brazilians and the Japanese whereby the later were supposed to reattain their 40% share. However, this was never accomplished as it seems that the Japanese were very worried about the financial performance of the company

Figure 7.1

EVOLUTION OF STOCK OWNERSHIP OF USIMINAS 1956-1977
PERCENTAGE DISTRIBUTION

Date	TOTAL Millions	Private Shareholders	SIDERBRAS	NIPPON USIMINAS	National Treasury	ESTADO DE M.G.	BNDE	Other Banks	ACESITA	CSN	CVRD	Others
1977												
1/10/1976	3.410,20	—	51,60	18,50	—	—	28,20	—	0,02	0,04	1,40	0,24
31/8/1976	2.885,00[a]											
30/6/1976	2.115,50											
14/8/1974	1.692,40	—	1,85	18,58	4,60	—	73,63	—	0,18	0,03	1,01	0,09
31/1/1972	1.208,50	—	—	18,73	6,57	—	73,13	0,09	0,08	0,04	1,42	0,04
1/12/1971	1.051,20	—	—	18,73	6,47	—	73,13	0,09	0,09	0,04	1,42	0,04
22/9/1971	525,60[b]											
30/6/1970	c	—	—	20,90	12,69	—	63,31	0,09	0,08	0,07	2,94	0,02
30/6/1967	365,00	—	—	18,82	12,69	2,52	62,88	0,09	0,08	0,07	2,83	0,02
31/5/1967	320,00 d											
23/4/1965	150,00	—	—	21,46	12,69	2,87	59,45	0,10	0,10	0,07	3,23	0,02
18/2/1962	18;000,00	—	—	40,00	—	23,95	24,64	0,86	0,80	0,62	9,00	0.13
20/1/1958	4000,00											
9/12/1957	3200,00	—	—	40,00	—	20,00	18,00	4,80	4,50	3,50	9,00	0,20
25/4/1956	5,85	100,00	—	—	—	—	—	—	—	—	—	—

NOTES: a) This increase actually took place in two stages
b) Through incorporation of reserves
c) Transfer of stock from the State of Minas Gerais to the BNDE and from the BNDE to Nippon USIMINAS
d) Through incorporation of reserves

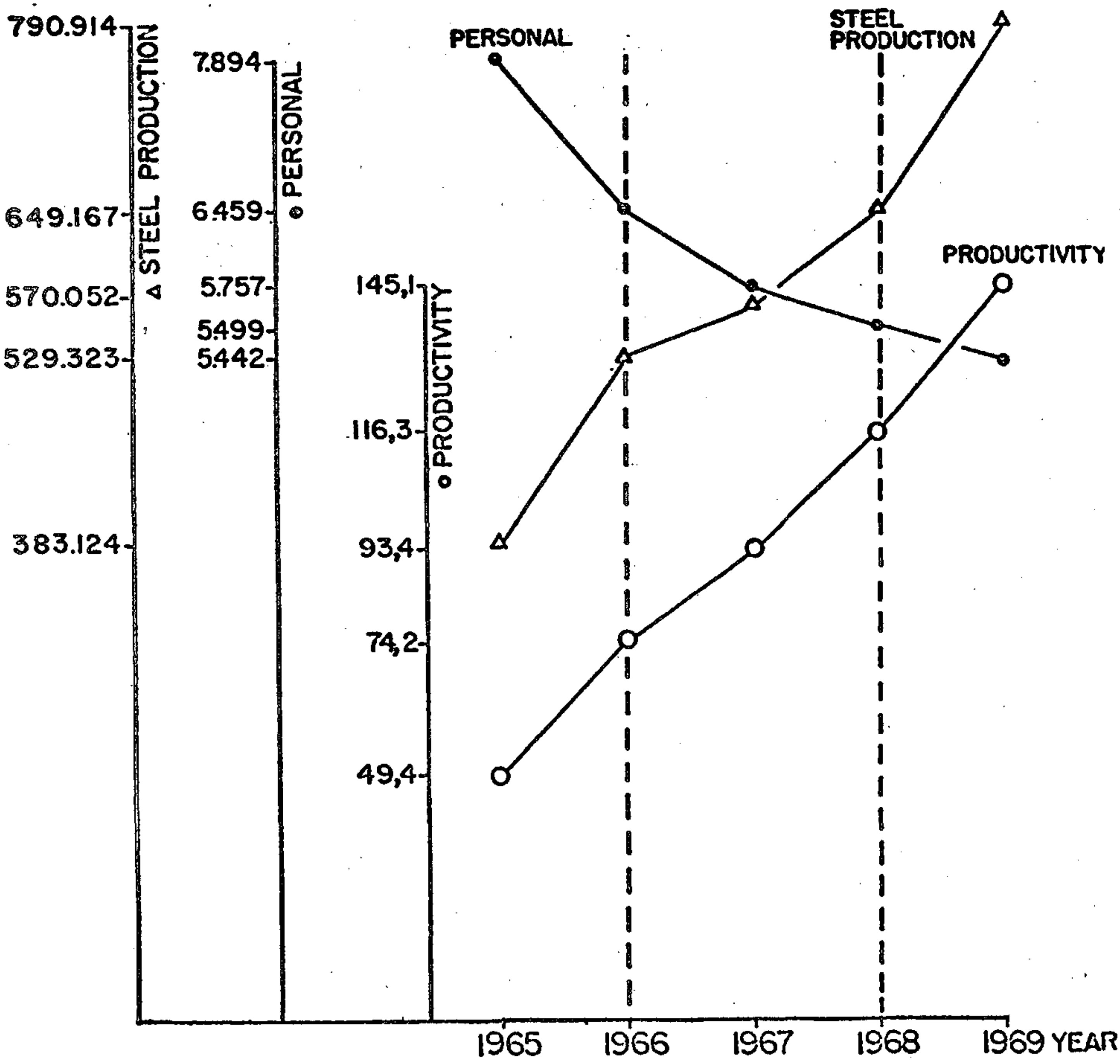
Sources: Alfeu Barbosa, "21 Anos de USIMINAS", USIMINAS REVISTA, Ano 8 Nº 16 (Julho 1977) p.47 and USIMINAS COMPANY REPORTS, 1956-1976.

were: 1) the introduction of the line staff system of administration under which line activities revolved around production and sales while staff activities were responsible for the maximization of performance and were to be carried out by newly created Industrial Engineering, and Metallurgy and Control Departments; 2) the introduction of the standard cost system as an administrative system for the control of results at all levels, and 3) the definition of Director's functions as those of a board responsible for the definition of policies and objectives of the firm, giving only the President executive powers.

Based on those BAHINT recomendation USIMINAS reduced its personnel from 7.800 to 5.500 at the plant between 1966 and 1968.[1] Figure 7.2 shows the reduction of personnel, production and productivity between 1966 and 1968. Notice that even as the personnel reduction was carried out production was increased, leading to a dramatic increase in productivity.

(1) Manoel Moacelio de Aguiar Mendes, "Geração da Tecnologia - O exemplo da USIMINAS", USIMINAS REVISTA; Ano 1, nº 2 (1970) p. 19.

Figure 7.2 PERSONNEL REDUCTION AND PRODUCTION INCREASE



7.2 The Implantation of the Standard Cost System

The most important part of the reforms from the point of view of the future technological development of the firm was the implementation of the standard cost system(1). With personnel from the newly created Industrial Engineering Department the BAHINT consultants went to each section of the firm and after discussing the various operations involved in each activity with the operation personnel, they worked out the goals to be attained and surpassed.

In a recent conference on the steel industry and scientific and technologial progress, Amaro Lanaro Junior(2), the man who was president of USIMINAS for 18 years (1957-1975) and is generally considered to have been the person most directly responsible for USIMINAS' technical evolution, divided the method of knowing and formulating the technological problems into four stages: observation, analysis, information and comparison.

Through observation the characteristic indexes of the particular production process in question are measured. These include production indexes, quality performance, rejects, losses, etc.

Through analysis the observations are sub-divided and each elementary operation is studied in detail trying to relate the observed indexes with qualities or defects in the raw materials, the equipment, or the training of the personnel.

Through information a search is made in the specialized literature, in contacts with equipment manufacturers, in technical pa-

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(1) It is claimed that the standard cost system, which had been developed in the U.S., was used by USIMINAS before it was used by Japanese steel plants and that, in fact, the Japanese who saw it implemented at USIMINAS were responsible for introducing it in Japan.

(2) Amaro Lanari Junior. "A Empresa Siderúrgica no Processo Científico e Tecnologico" FUNDEP -Fundação de Desenvolvimento da Pesquisa: Simpósio sobre Ciência e Tecnologia em Universidade, Instituto de Pesquisa e Empresa, Belo Horizonte, 27 de abril de 1977.

pers, or through the direct knowledge of the experience in the best enterprises in the industry, for the production indexes which are good or excellent by current international standards in the present state of technology.

Finally, through <u>comparison</u> an identification is made of the strong and weak points in technique, of the deficiencies and of the defects in own process as compared to those of similar enterprises and of the indexes which have to be improved.

By going through these four steps, Lanari suggests, the size and nature of the problem and the technological diagnosis of the enterprise can be made.

From the outline presented it is obvious that the basis of the support and control structure for the methodical and routine identification of the technological problem of the enterprise is the standard cost system. Once the standard cost system is formulated all the way from each elementary operation up to each of the cost centers and on to the whole operation of the enterprise, the variations in each standard element observed through out the month become the basis of points to be debated, explained and resolved.

The general picture of standard costs and all its variations (1) gives a measure of the technological level of the enterprise and serves as the basis for observation, analysis and comparison with internationally accepted standards in order to identify the problem to be solved and the new goals which are to be set and gradually attained. The standard costs and goals are constantly revised and higher goals set. In order to accomplish this there have to be a whole series of technical support departments. The enterprise must not only be looking at and analysing its own technology, production and productivity inde-

(1) These are presented in physical imput as well as in price terms so it is possible to separate out the influence of changes in prices from that of changes in imput.

xes but must also be searching for information on the performance and technology of other plants and on the development of the technological frontier.

It means that within the firms there must also be a well developed mechanism to analyze the causes of the problems and to develop their solutions. In practice this means that a lot of departments are involved. Once the production personnel identify a bottleneck they need the cooperation of the Department of Industrial Engineering to decompose the operation into its elementary operations and to study alternatives. The personnel from the Department of Metallurgy and Quality control help to identify the problems which they are not prepared or equiped to study and appeal to the Research Center to learn about and correct the causes for low performance. The Maintenace Department knows the weak points and deficiencies in the equipment and advises the Engineering Department to correct those defects.

There is thus a complex interaction betweem the production departments and the support departments, between information on internal technology and technological indexes and between information on external technology and technological indexes in other plants or in the technological literature. In the case of USIMINAS it was largely through the effective development of this mechanism that it was possible to carefully study its existing equipment, compare its performance to that of other plants, and in that way stretch the capacity of the existing equipment to its limit. It should be noted, however, that its effective implementation required the active development of the firm's technological and organizational infrastructure. With the BAHINT reform a Department of Industrial Engineering and a Department of Data processing were established as the basic instrument to measure operational efficiency. In addition, the Departments of Metallurgical Control, Planning and Coordination of Production, were restructured to give suppot to production.

In 1967 the training of personnel for the research center to be set up later was started by sending personnel abroad for training.

In 1968 a Center of Technical Information was created.

In 1970 the research Center was set up.

In 1971 USIMEC, a subsidiary for the manufacture of steel equipment, was created and the Research Center was innagurated.

In 1972 the data processing center was restructured and a special group with the task of developing the automation of production processes was organized.

In 1974 a Department of Information Systems (Computer) was created.

In order to explain a bit more clearly what the functions of some of these departments are, a brief description of the most important is given below: In addition Appendix IV gives some selected case examples of the type of projects the main ones carry out.

7.2.1. Metallurgical Control and Plant Inspection[1]

This department is in charge of analysing, absorbing and applying all the metallurgical techniques acquired and developed by the firm. Its main reponsibilities are: specification of raw materials and products, the establishment of quality and operational controls, participation in the development of new products and processes, and the analysis of the behavior of the products in use by clients. It is also in charge of coordinating at the plant site all the technical services given to Operation by external firms.

(1) The information in this Section is based en COTA, "Investimentos... p. 31

One of the most important functions of this departments is to give technical support to Operation; it carries out metallurgical studies aiming to improve the efficiency of the processes, the qualities of the products, and cost reduction. Another important activity is the routine analysis of operational results which permits that the production departments are constantly informed on the achievement of the standards and quality goals set. All industrial scale tests for the implantation or modification of standards are done through this department. Also, it serves as the link between Sales and Production personnel in the implantation of new products demanded by the market. Finally, it is also through it that the greater part of the ideas generated in the Research Center are put practice.

In 1976, it had 127 persons in the area of Metallurgical Control, 32% with higher education and 34% with technical education; and another 370 in inspection activities.

7.2.2 Industrial Engineering[1]

The main functions of this department are: maintaining the standard cost system, economic analysis of alterations and improvements in production processes, operational evaluation and applied mathematics, control and determination of material inventory levels, method, time and motion studies and determination of labor force.

In 1976 the department had 80 persons. Fifty three percent had a higher education level, 38% had a technical education and 9% were administrative.

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(1) COTA, Op Cit, p. 31

7.2.3. Information Services

As already pointed out an efficient and effective information service is an essential part of the technological infrastructure of the firm. The firm needs information to define correctly which are its technological needs and to be able to obtain that technology in the most economical way possible. This requires obtaining information on modern techniques of production and control, productivity and quality indexes achieved by other firms, trends in the steel product market, etc.

USIMINAS has centralized these functions in a Center of Technical Information. Among other things this center has the best library on steel in the country and maintains permanent contacts with the main information organs in the country and in the world in order to collect information of interest. The CIT regularly publishes several publications among which are a monthly patent Bulletin, a bi-weekly series on Bibliographical Information. Recently it has started to publish a series of reports on the general state of steel technology It has also started to publish a series on general macroeconomic conditions in the main steel producing countries including excepts and abstracts from relevant articles.

The Research Center has its own technical library staffed with 19 persons with over 5,000 books and its own subsription to 329 revelant technical journals and magazines apart from those of the main library.

The Research Center's library regularly circulates a monthly periodical index; monthly Tecnical News Bulletin, which carries information and abstracts on the most recent innovations which have occurred in the various sectors of steelmaking; and a monthly Information Bulletin, which gives bibliographical references of all the literature received and all the bibliographical research undertaken during the month.

As will be discussed in section 7.4., besides the Center of Technical Information, the Superintendency of Research on Processes and Information in the General Superintendency of Engineering is another information collecting organ.

7.2.4. Computer Systems[1]

Allied to general administrative reform of 1966 USIMINAS adopted data processing. Initially this was done through IBM but by 1968 they had installed their own IBM 360 at the plant. At the beginning it was used primalily for administrative and financial services. Since then, however USIMINAS has started to use it for production related purposed as well. By 1971, it was being used to compile basic statistical data on production and raw material consumption for the blast furnaces and steel shop, and for programming control and operational indexes of the rolling section. Its use was also being extended to the coke and sinter plants as well as to inventory maitenance control. By 1972, the original IBM 360 system reached its capacity and plans were made to adopt a new IBM 370 system which entered into operation in 1973. With its entry it was possible to start implanting an Operation Control System in the areas of steel shop and hot rolling. This is system comprises all operations which go from receiving a

(1) Information for this section is based on José Roque Rossi, "O Uso do Computador na Gestão Empresarial" USIMINAS REVISTA, Ano 2 nº 3 (1971) pp. 69-72; Roberto de Freitas Ramos and Romeru Pries Gouveia "Teleprocessamento de Dados na USIMINAS" USIMINAS REVISTA, Ano 3, nº 5 (1972) pp. 55-60; Paulo Roberto de Carvalho Coelho, et. al "O Computador no Planejamento e Controle de Produção da USIMINAS" USIMINAS REVISTA Ano 4 nº 7 (1973) pp. 52-7, the company's Annual Reports 1972-1976, and Cota, "Investimento ..." p. 32.

purchase order to production programming. A second IBM 370 was installed in 1974 and the functions of the system expanded further. In 1975 a computer system for the calculation of the end of oxygen blowing was implanted in Steel Shop nº 1 and a terminal for the execution of charging and other calculations were installed for the third blast furnace.

It is our understanding that USIMINAS is currently installing automatic computer process control of the steel shops and the third blast furnace, and eletricity demand.

In 1976 the number of people involved in the Computer activities was 201. Thirty percent are university trained specialists, 30% are middle level technicans, and the rest are administrative staff and operators. The system has grown significantly since then, but we do not have any more recent information on staff.

7.2.5. The Research Center

This section on the Research Center will be more detailed than the others in order to show the step by step proceedure adopted, and to give idea of its evolution and of the type of projects is has undertaken.

It is our understanding that initially it took a lot of persuasion to sell the idea of the Research Center to the Operation personnel This was finally accomplished when USIMINAS started to have operational problems in the blast furnaces as a result of a switch in the source of the mineral ore which was being used. The production personnel were then finally convinced that it would be useful to have their own research center which could help to analyse and solve such problems

Planning for the research center began in 1967 with the selection of a team of six engineers who were sent abroad(1) for training and specialization. In 1969 USIMINAS signed a five year contract with its Japanese partner NIPPON USIMINAS for the specification of - equipment and training of personnel. The research center itself was inagurated in 1971. It is one of the eight staff departments directly subordinated to the General Chief of Plant at Ipatinga (2). Although it originally started out with five(3) sections it is currently subdivided into seven sections: pig iron research, (46 people) steel research (21 people), process research (26 people), product research (36 people), chemical analysis (39 people), instrumentation unit (51 people). The first four units are development units . They carry out studies corresponding to the main production activities of the plant, for the support sectors, and for third parties. The last three are support units which service the first four research units develop methods of analysis, and project and set up equipment for the specific projects of the Research Center.

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(1) Four went to Batelle Memorial Institute (U.S.A.) two went to IRSID (France).

(2) The other seven are: Metallurgy and Inspection, Industrial Engineering, Information Systems, Industrial Relations, Industrial Acounting, Planning and Control of Production, Supply. (See figure 7.7)

(3) Until 1976 chemical analysis and instrumentation were one unit. Until 1978 process and product research were one unit.

In the initial planning, the work to be done by the research center was divided into three broad areas:(1) TECHNICAL SUPPORT: the study of raw materials, especially mineral ores, and coal, with the objective of improving the technical and economic conditions of their utilization in the blast furnaces; studies on the metallurgical factors which influence the yield of the process or the quality of the process, as well as the better utilization of the products; studies on materials consumed in the plant such as refractories and ingot casts, with the purpose of improving their utilization; studies for the introduction of new techniques and the maximum utilization of existing equipment. DEVELOPMENT RESEARCH: development of new products and experimentation of new processes as well as substancial improvements in the production and quality indexes, using laboratories and pilot plants. APPLIED RESEARCH: practical exploration for the creation of new products and processes through technological and scientific laboratory research.

According to planning in 1970 initially 100% of the effort was to be concentrated on technical support. In five years they planned to devote 65% of the effort to technical support, 30% to development research and 5% to applied research.

In 1977, the main objectives of Research Center were stated as:(2)

1 - Analysis of raw materials available for the steel industry from various sources in the sense of defining those which in certain conditions offer the firm greater economy.

2 - Improvement in the efficiency of the processes employed and feasibility analysis of the introduction of new processes with the objective of reducing production costs by reducing energy consumption, increasing production, and increasing process yield.

(1) Amaro Lanari Junior, "Pesquisa Tecnológica na Empresa" USIMINAS REVISTA, Ano 1, nº 2 (1970) p. 12

(2) Francisco Leal Lanna and João Luiz R. Pimenta, "O Centro de Pesquisas" USIMINAS: Simpósio de Pesquisas em Administração de Ciência y Tecnologia, SP, Dezembro,1977.

3- Improvement in the quality of the products manufactured and development of new products with the objetive of supplying the consuming market products with the quality demanded and superior to that of competitors.

4- Give assistance to all units of the plant in the solution of technological problems.

5- Cooperate for the raising of technical knowledge in all the units of the plant.

6- Give technical assistance to National firms with the objective of cooperating with the technological development of the country.

7- Development research work in conjunction with the University with the objetive of fostering the integration of the University and the enterprise according to Government directives.

Notice that development research has now been dissagregated into product (item 2) and process (item 3) research as also reflected by the distinction between the product and process research divisions. Notice also that lending technical assistance services to third parties is explicitly stated (item 6), and that closer work with the university is being sought(item 7).

The 1977 distribution of the technological effort of the Research Center is summarized in figure 7.3. Research projects accounted for 42.2% of the total number of projects and for 69.0% of the costs which shows that they are relatively more expensive than projects for technical support or for third parties. Technical support projects accounted for the largest share of the projects (52.4%) but for the relatively lowest share of the costs (26.7%). Research services for third parties were 5.9% of the projects and 4.3% of the costs. In terms of the overall distribution of the Research Centers costs the greatest portion (33.0%) was process research, followed by product research (23.6%), techniques and methods (20.7%), imputs (14.1%), and development and improvement of equipment and instruments (8.6%). As can be seen in the figure ,however,the relative share of each of these types

Figure 7.3

DISTRIBUTION OF THE TECHNOLOGICAL EFFORT OF THE USIMINAS RESEARCH CENTER (1977)

Nature of Work	Area	Number of Project	Cr$ Spent (1977)	RESEARCH EFFORT AS % OF EXPENSES: Process	Product	INPUT: Energy	INPUT: Raw Materials	INPUT: Others	Techniques and Methods	Development and Improvement of Equipment and Instruments	TOTAL
Research of Projects	Reduction	23	15.838.762	1,16	11,12	2.37	4.28	-	16,55	0,20	35,68
	Refining	9	10.081.230	14,62	-	-	-	-	8,09	-	22,71
	Rolling	22	15.488.072	22.04	8,04	0.57	-	2,02	0,89	1,33	34,89
	Others	2	2.983.086	5,12	-	-	-	-	-	1,60	6,72
	Sub Total(1)	56	44.391.150	42,94	19,16	2,94	4,28	2,02	25,53	3,13	100,00
Technical Support	Reduction	7	4.868.088	0,69	-	-	16,73	-	8,61	2,31	28,34
	Refining	10	3.543.707	6,73	-	-	-	-	9,33	4,57	20,63
	Rolling	31	7.815.737	4,67	14,89	-	-	10,66	1,14	14,14	45,50
	Others	24	[illegible]9.913	0,63	-	-	-	0,62	0,81	3,47	5.53
	Sub Total(2)	72	17.177.445	12,72	14,89	-	16,73	11,28	19,89	24,49	100,00
Research Services For Third Parties	Reduction	3	481.354	10,29	-	-	-	-	-	7,11	17,40
	Refining	-	-	-	-	-	-	-	-	-	-
	Rolling	5	2.285.051	19,59	63,01	-	-	-	-	-	82,60
	Others	-	-	-	-	-	-	-	-	-	-
	Sub Total(3)	8	2.766.405	29,88	63,01	-	-	-	-	7,11	100,00
Grand Total		136	64.335.000	33,00	23,59	1,75	8,04	4,3	20,74	8,58	100,00

Source: Information supplied directly by USIMINAS of technological effort varies depending on the nature of the projects. Over 40% of the effort in research projects was on process research whereas product research was less than 20%, and techniques and methods was over 25%. On the other hand technical support was more or less evenly distributed among all the categories with the largest share going to development and improvement of equipment. Finally, almost all the effort of Research services for third parties was for product and process research with a clear emphasis or products rather than process which is the opposite of the case in research projects.

In the last three years approximately 60% of the activities of the Research Center correspond to technical support and 40% to formal research projects. Of the latter, 70% are related to process development and 30% to product development. Ten of the 50 projects currently underway are being done for third parties such as SIDERBRAS, PETROBRAS, AÇOMINAS, etc, with an estimated gross income (1978) in the order of Cr$ 15 to 20 million.

It should be noted that since the beginning an effort was made to have the Research Center be in close contact with production. The technicians which were sent out for training and specialization abroad first had to spend some time at the plant to familiarize them with its specific problems. Currently personnel sent abroad first spend a minimum preparatory period of three years at the plant.

In addition, from the very begining a research desk was set up in each of the productive departments. A delay of almost two years in the installation of the research center and its equipment provoked a high turnover rate among the personnel initially sent abroad and some problems in the relationship between research and production The period 1970-1972 was considered an adaptation stage. Betweeen 1973 and 1975 a good relationship between research and operation was achieved. During the last three years in fact, the Research Center has passed from being the one seeking to solve problems in the operation area, to being sought by that personnel to solve their problems.

Fixed investments in the Research Center total four million dollars. Forty eight percent were obtained throught an Inter-American Development Bank loan for equipment purchased, 24% from the Fondo Nacional de Desenvolviment de Ciencia e Tecnologia and 28% from USIMINAS' own resources. Equipment[1] accounts for 62% of the total and buildings for the rest. As of 1977 nearly 70% of the equipment had already bein been installed and nearly 80% of the building had been done.

The annual operating budget of the Research Center is fixed at 0.5% fo USIMINAS' gross sales.[2] Figure 7.4 gives the annual budgets since its implantation in 1971. The total budget in 1977 was US$ 5 million (approximately 75 million cruzeiros) and was distributed as follows: personnel 73%, research supplies 9%, work by third parties 8%, equipment and construction 10%.

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(1) In 1975 Research Department was equipped with: a sintering pilot plant, pilot coke oven, coal bricketing and reduction, vacuum induction furnace of 50 kg, and atmospheric induction furnace of 100 kg; pilot rolling mill line, with 2-High and 4-High mill (rolling charge capacity of 250 tons., 0.1 mm - 0.01 mm minimum thickness, 300 mm maximum width), down coilers, heating and annealing furnaces, mechanical tests , dilatometer formator-f for heat treatment CCT and TTT; optical microscope and quantimeter, X-Ray diffractometer , X-Ray micro-analyser, 200 kv transmission electron microscope, scanning microscope with energy dispersion system (EDS); a chemical laboratory equiped for instrumental analysis for raw material, slag, gas, oil, pig iron and steel; electronic instrumentation laboratory and machine shop.

(2) This is close to the figure in the U.S. industry where the average is 0.60% of sales. However, in the Japanese industry it is 0.78% although Nippon Steel spends 1.50% (Source: Francisco Lanna Leal, Chief of Research of USIMINAS)

Figure 7.4.: Research Center's Operating Budget

(1,000s of current cruzeiros)

YEAR	OPERATING BUDGET
1971	3,841
1972	5,064
1973	7,387
1974	12,088
1975	24,674
1976	38,325
1977	67,500

Source: 1971-1976 Computations based on 0.5% of Gross sales figures given in Companies annual reports

Currently the total staff of the Research Center is 258. Twenty two percent have higher education, 34% have a technical education and 43% are administrative, or laboratory workers and equipment operators. Between 1967 and 1977 thirty three persons were sent abroad for specialization and training for the Research Center. Forty percent of that training and specialization has been at Nippon Steel with which USIMINAS had a technical assistance and training contract for the Research Center between 1970 and 1975. USIMINAS is currently negotiating a second five training contract.

The research plan for year is based on the solicitations of the various units of the enterprise within the guidelines set by the high administration. A preliminary plan is elaborated by the Research Center after discussion with the various operating sections. The preliminary plan is examined by the Head office at the plant which defines priorities and chooses the actual projects. These are analyzed more carefully and detailed with repect to stages and resources necessary. Based on this the final plan is elaborated and presented to the high administration.

Together with the yearly plan a five year plan which serves as the long term plan for equipment purchases and personnel contracting is elaborated.(1)

Currently the Research Center is developing close to 50 research projects and 70 technical support projects . A general sketch of the main activities of the Research Center in the past few years is given below.(2)

1971 - 16 projects were concluded and the development and another 9 were started.

1972 - 16 research projects were concluded, among them were the development in industrial scale of a new product line (eletrical plates with silicon) and of research on the utilization of sub-products of coke gas.

16 technical support projects were carried out. The preparation of patent solicitation for 14 inventions were carried out. Four patent solicitations were published.

1973 - 26 research project relating to steel processes and development of instrument techniques for chemical analysis were completed

75 technical support projects were carried out. 32 of them were directly related to fullfilling the quality and productivity goals of the enterprise.

3 more patent soliciations were deposited with the Instituto Nacional de Propriedade Industrial.

1974 - 15 research projects were concluded. Among them were one which sought more rational utilization of excess combustion gases generated in the plant, one saving 20% of fuels used in the blast furnaces, and one for increasing the production of the plant another one million tons with the same equipment.

51 technical support projects were concluded.

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(1) Lanna and Pimenta, Op Cit pp. 12-14

(2) This information was collected from the Companys annual Reports 1971-1976.

1975 - 40 of 48 research projects planned were concluded. The others were transfered to the next year because of delays in the installation of equipment. One of the most significant projects undertaken was "The Midrex Process as Used by USIMINAS" which is for the use of coke oven gas for direct reduction and may permit the plant to produce 4.5 M.t.a. with the equipment projected for 3.5 M.t.a.

88 technical support projects were carried out. In addition the Research Center continued a technical assistance program it had initated with SIDOR of Venezuela for training research staff for that steel plant's research department.

1976 - 48 research projects were carried out.

103 technical support projects were carried out.

11 more processes were prepared for patenting.

Among the highlights were the development of 5 projects for other enterprise: 2 on mineral ores, 1 on the utilization of babaçu nuts, manganese and iron from the new deposits at Carajas for sinterization done for SIDERBRAS, 1 on briqueting babaçu coal for the Cia Industrial Técnica do Maranhão; and 1 on the development of high resistance steel for the Centro Técnico Aerospacial.

Recently, the firm has felt the need for more basic research which is beyond the scope of its in-plant research center. There is an interest in setting up a central research center away from the plant to carry out the more basic research. In theory, this would be a cooperative research center financed by the steel firms and the state which would tackle the basic research problems presented to it by the member firms. However, this is still at the preliminary talking stage with no concrete comitments from any of the parties involved.

7.2.6. Others

We were not able to obtain information on two other important departments. The Department of Planning and Control of Production and the Maintenance Department. In terms of maintenance, however, we know that each operating department has its own maintenance section distinct from the Maintenance Department proper.

7.3. An Aside on the Technological Prism

The development of a plant's technology takes place within the context of the need to maintain competitivity in a market where new products, higher quality standards and new ways of producing more efficiently are constantly appearing. These demands of the market imply a need to constantly select, absorb and adapt external knowhow.

An interesting insight into USIMINAS' strategy with respect to the need to import is given in two articles by high administrative officers of the company. The main argument is that importation of foreign technology should not be seen as an end it itself, but as a means to enable the firm to develop technologically and to create profit opopportunities. One of the objectives of the Research Center is to attend to that need. However, the simple existence of a research center is not a sufficient condition. Enginering services are also necessary to transform the conclusions of research into a project. Engineering services, in turn, need basic experimental data because the licensors of processes try to hold back on these data and on methods of dimensioning the equipment in an attempt to neutralize national engineering. For that reason it is necessary for national industry to create infrastructure which permits it to dissagregate the technological package through technological and scientific knowledge and to develop the know-how acquired. They suggest that Research and Engineering constitute an innovative capacity in the enterprise and that between them there must be a joining of efforts. However, for that capacity to be used efficiently, it is necessary that it be allied to the ability to apply that knowledge in equipment manufacturing. Furthermore, that system still needs an indispensable component which is the feed back supplied by those who use the equipment and the process - the people involved in operation and control of the plant's production. Research, Engineering, Equipment, Manufacture and Production thus form what they refer to as four planes of a technological prism.

(1) Manoel Moacelio de Aguiar Mendes "O Papel das Organizações de Engenharia no Processo de Desenvolvimento Technológico" USIMINAS REVISTA Ano 6 nº 12 (setembro 1975) pp. 25-29 and COTA, "Investimentos ... Op. Cit., pp. 29-21.

Based on that philosophy, USIMINAS created the Research Center, then a Superintendency of Engineering and USIMEC, a subsidiary to manufacture capital goods, which in 1972 became an independent enterprise with stock participation by USIMINAS[1].

Cota[2] adds that in terms of transformimg the results of the research work into practice or products an interaction is necessary among Research, Metallurgical Control and Sales. Metallurgical Control, which is responsible for the establishment and observance of operational standards, informs the researcher on the limitations of the industrial process, and is in charge of programming and undertaking experiences on an industrial scale. An interaction between sales and research is necessary not only with respect to marketing in order to identify threats or new market opportunities, but also for the commercialization of new products. In the latter case technical studies and follow up on performance with the clients are decisive in the acceptance of a new product.[3]

An interesting point on USIMEC is that since it became totally independent there have been jealousies between it and USIMINAS about what each is learning, and that the flow of information has been considerably impaired by bickering on what sort of payments should accompany the flows. Apparently this problem exists more generally between equipment producers and their clients, as is exemplified by the problem between Ishikawajima and Nippon Steel with respect to the large size blast furnaces mentioned earlier.

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(1) In 1968, USIMINAS created a Special Advisory Group for the promotion of the use of steel in civil construction which was then limited to concrete technology. The need to have an organization which could act in the market led to the creation of USIMEC in 1970. Its main objective was to build metal structures, bridges, roads, and railways. In 1973 it broadened its objectives to manufacture capital equipment for the steel industry. It is now one of Brazil's major capital goods suppliers. See Appendix V for more details on USIMEC.

(2) COTA, Op Cit, p.31

(3) As an example of the latter, Volkswagen recently complained to USIMINAS about the quality of the surface finish on the steel sheets it was purchasing. They were having problems in the phosphatization base which was applied before painting. The Research Center was asked by the marketing department to look into the matter. The center did an exhaustive study including electron microscopy on the optimal properties of the metal finish for phosphatization was able to show that the problem lay not in the finish, but in the technique used by Volkswagen.

7.4. Expansion Plans, The Development of Engineering Services and the Emphasis on Basic Engineering

7.4.1. Engineering in the First Expansion Plan

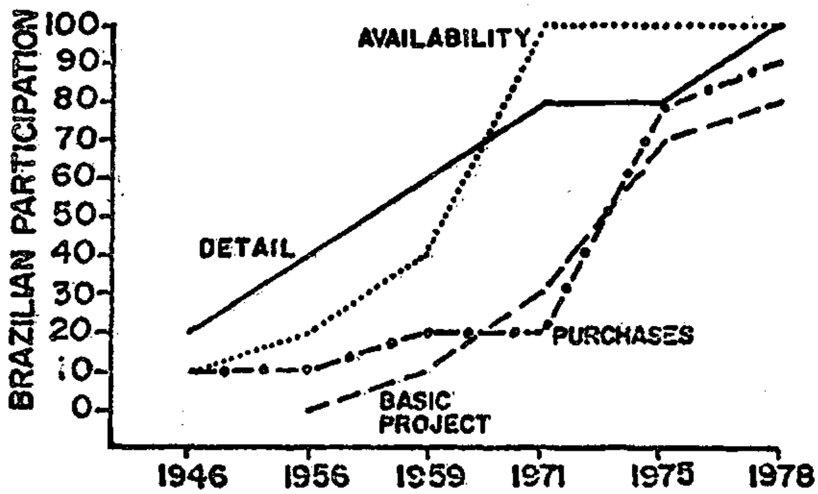
The Development of the engineering element of the technological prism is very related to the companys expansion plans. As will be recalled from chapter three initially all the engineering for the plant's creation was done by the Japanese partners. It should also be recalled that its first expansion plan to increase production to 1.4 M.t.a. was done by the Japanese, who were primarily responsible for all the engineering. When that plan was approved by the Government in 1968 USIMINAS created an Engineering Nucleus for the Coordination of Expansion Services which was called the Expansion Group. It was responsible for all aspects of the implementation of the expansion plans although it was still organized under the premise that the bulk of the work would be done by consultants, equipment suppliers, engineering firms, and construction subcontractors.

It should be noted that until recently project engineering was not too well developed in Brazil. This can be seen in figure 7.5. which is taken from a recent study on Brazilian engineering capacity that is one of the studies for the Master Steel Plan mentioned in chapter five.(1) Within the definition of engineering services developed in that study a distinction is made among

(1) Luiz Eduardo Klinger Abreu, Chief of the General Superintendency of Engineering of USIMINAS presentation on "The Problem of the Adequation of Production Processes for Capital Goods". contained in MIC-STI _Industrial Technology Week: Capital Goods Industry_ (São Paulo, September, 1975) p. 298.

planning and project engineering[1].

FIGURE 7.5 DEVELOPMENT OF BRAZILIAN ENGINEERING CAPACITY IN STEEL PROJECTS



SOURSE - COSRAPI NOTICIAS 4/1965

Cited in Roberto Tambasco et al "Uma Apreciação da Engenharia de Projetos Siderúrgicos no Brasil", in ILAFA, Inginieria y Fabricacion de Equipos Siderurgicos en America Latina (Rio de Janeiro: 1978 ILAFA Congress).

Taking 1959 as the base year for when engineering services were required for the initial construction of USIMINAS and 1970 as the base year for the engineering necessary for the large expansion plans, the Brazilian participation was as follows:

	1959	1970
Feasibility studies engineering	40%	82%
Basic project engineering	10%	28%
Purchase engineering	20%	20%
Project detail engineering	60%	72%

Notice that the two areas where Brazilian capacity were still very weak in 1970 were basic project engineering and purchases.

(1) Planning consists of basic conception which involves a preliminary market study, location, product mix, production plan, processes, specifications, fluxograms, chronograms and general lay-out; and a feasibility study which involves a market study, investment, infrastructure and worker availability, operating cost estimates, definition of location, and technical, economic and financial analysis as well as sources of finance. Project engineering consists of the basic project, purchases, and detail. The basic projects engineering refers to layout, selection of equipment, general specifications, technical planning of

7.4.2. Japanese Engineering Assistance For the Second Expansion Plan.

As mentioned earlier the IBRD and IAD banks lent USIMINAS 105 million dollars for the second expansion plan. As part of the loan agreement they required USIMINAS to contract a consulting firm of large experience to serve as an advisor for the plan. USIMINAS chose its old partner Nippon Steel Corporation.

The flow of engineering services in the second expansion plans is presented in figure 7.26 below. Four main parties were involved: USIMINAS, Nippon Steel (the consultant), Suppliers and Builders.

USIMINAS prepared the basic plan and then worked out the detailed plan, construction cost estimates, acquisition classification and construction chronogram with Nippon Steel. This comprised the technical study phase. The rest comprised technical engineering for the

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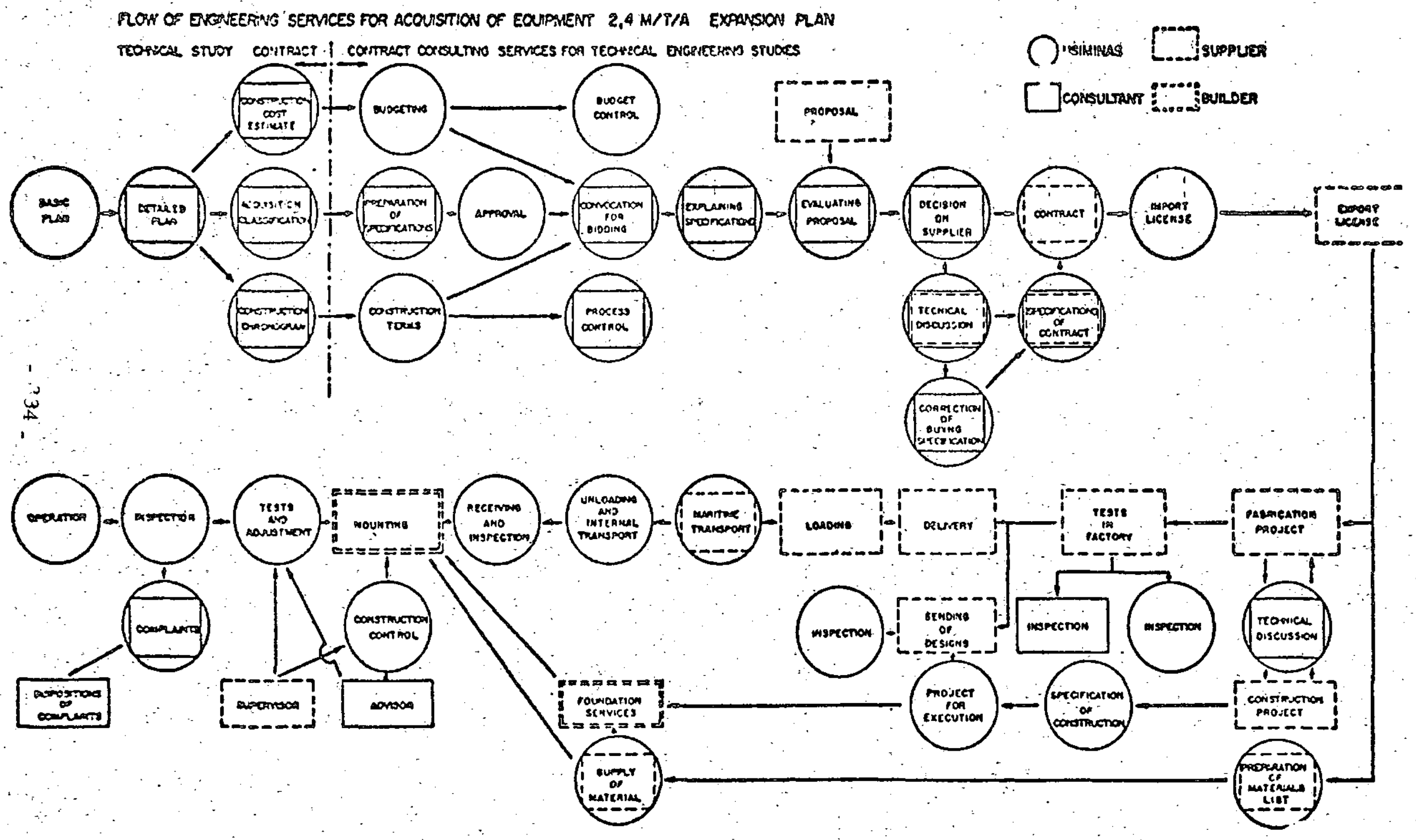
Footnote continued from previous page
acquisition, detailled specifications of equipment units, prequalification of bidders, technical analysis of the proposal, and approval of suppliers designs. Purchases engineering refers to cataloguing of suppliers, preparation of purchase documents, organization of bids, emission of bidding invitations, clarification meetings, commercial evalution of the bids, adjudication of orders, and inspection. Detail engineering refers to construction execution, installation of materials, specific materials lists, and revision of designs for alterations in the construction.

plan itself. The specifications were prepared by USIMINAS with its advisor. USIMINAS then approved the specifications and called for the bids in conjunction with its advisor. Notice that construction budgeting, budget control, and construction periods were set by USIMINAS, although the control of the process was done in conjunction with its advisor. The explanation of the specifications to the bidding parties, evatuation of the bids, and decison on suppliers, technical discussion with suppliers, correction of the buying specifications, and specifications of the contract were all done in conjunction with the advisor. USIMINAS and its advisor then had technical discussions with the supplier for the project and construction of the equipment, and with the civil works contractor for the foundations and buildings. USIMINAS specified the civil construction and after receiving designs from the manufacturer, elaborated the project for execution by the foundation contractor. Control of the construction and mounting was done by USIMINAS with the help of its advisor. The equipment supplier also supervised the amounting and the testing and adjustment which was done by USIMINAS with the help of its advisor. Operation of course finally rested with USIMINAS.

Figure 7.6



Source: USIMINAS REVISTA, Ano 5 Nº 10 (December 1974) p. _

Besides giving an idea of the complexity of the engineering and planning process involved in the elaboration and implementation of the expansion plan, the above schematization serves to show the interration ship with the advisor. Notice that USIMINAS always maintained control of decisons. It relied on the advisor to help in the details of the planning and in all aspects of acquiring and installing and testing the equipment. Notice too that all these phases were done in conjunction so that USIMINAS must have learned all the fine points of such arrangements so that it was in a position to do them all itself by the third expansion plan.

7.4.3. The Development of Basic Engineering Capacity

In terms of the development of the internal organization to accompany the expansion effort the sequence was as follows. In 1970 the General Superintendency was turned into the General Superintendency of Operation to attend to the plant's normal operational activities and a General Superintendency of Development was created to attend to the coordinated development of the plant's expansions.

By 1972 the General Superintendency of Development was already subdivided into the Superintendencies of Planning, Project Engineering, Technical Services and Construction, and had absored the functions of the old Expansion Group. The main emphasis of the Superintenency of Development was still the implementation of expansion plans. Although it already had the basic elements for the development of capacity in basic engineering this was hampered by the day to day pressure of supervising operations to ensure that the expansion deadlines were met. Also, to some extent, the dependence on the Japanese, although beneficial for the fullfillment of the programs, made it difficult to fully develop this capacity[1]

(1) Luiz Eduardo Klinger Abreu, Op. Cit., p.298

Although USIMINAS' original goal was to do 50% of the various types of engineering for the expansion plan their effective participation turned out to be only 30%. The rest was done by the Japanese.(1)

However the goals for steel expansion set by the national government and its policy that there be the greatest possible degree of national participation in the steel equipment installed from then on had important effects on the further development of USIMINAS' engineering structure.(2) USIMINAS identified three areas which would have to be developed to make the Government objectives possible. The first was the basic engineering capacity of the steel firm since the units had to be made to order and it had the best knowledge of what it would need as well as experience accumulated from the operation of its older units. The second was the engineering of the individual equipment units and their details. Finally, the third was the engineering of actual equipment manufacture which was the area of the equipment producers. World experience was that the engineering in the second area was done by engineering firms with close links to steel firms from which they drew on the original designs, operational experience and the feedback of that experience on changes in the designs.

Keeping that in mind, USIMINAS hired a consultant to do a survey of the capacity of capital equipment and engineering firms in Brazil related to the steel sector. More than 80 firms were visited. The conclusion was that in terms of capacity to build individual units (rather than all the units necessary) the national industry could build 80% of the equipment. The weak point was the project engineering for the individual units, but it was felt that it could be overcome with assistance from steel firms to the equipment manufacturers. Concretely the former could: 1) supply drawings

(1) Information supplied by Amaro Lanari Junior

(2) Luiz Eduardo Klinger Abreu, Op. Cit., p.298

from which to copy equipment, 2) supply their experience with which equipment could be improved, and 3) give feed-back on the experience with the new equipment manufactured so that the equipment s pplier could perfect his product.(1) To accomplish that USIMINAS would have to assume a greater and more direct role in the supply of basic engineering to structure equipment packages for the bids, increase the amount of details contained in the specifications and designs, etc.(2)

As a result, USIMINAS decided to emphasize the activities of basic engineering in order to support the needs of its expansion program and fullfill the government objectives of increasing the participation of national equipment manufacturers in the expansion.(3) The organization of basic engineering then existing had to be strengthened. This involved increasing the capacity of process engineering in terms of quantity and quality, and in assuming though detail engineering greater responsibility going sometimes to the level of specifying manufacturing in the initial phases of nationalization.

This led to a restructuring of the Superintendency of Development. In 1975 it was divided into two superintendencies - the a General Superintendency of Engineering and the General Superintendency of Construction. The former in turn consists of a an advisory group on planning and installations and five subdivisions. The first is that of Process Engineering which is in charge of selecting the processes most adequate for expansion plans or improvements of installations, and for the coordination of all the technical activities necessary to complete every project. The second is that of Basic En-

(1) Amaro Lanari Junior presentation on theme "The Problem of the Adequation of Production of Capital Goods" contained in MIC-STI Semana Tecnologia Industrial: Indústria de Bens de Capital (São Paulo, Setembro 1975) pp. 294-297, 322-323.

(2) Luiz Eduardo Klinger Abreu, Op. Cit., p. 299

(3) It should be remembered that USIMINAS is a State controlled company which gives it aperspective wider than narrow profit maximization as well as makes it able to embark or such wider programs because to a certain degree it is not so dependend or internal capital generation for its development.

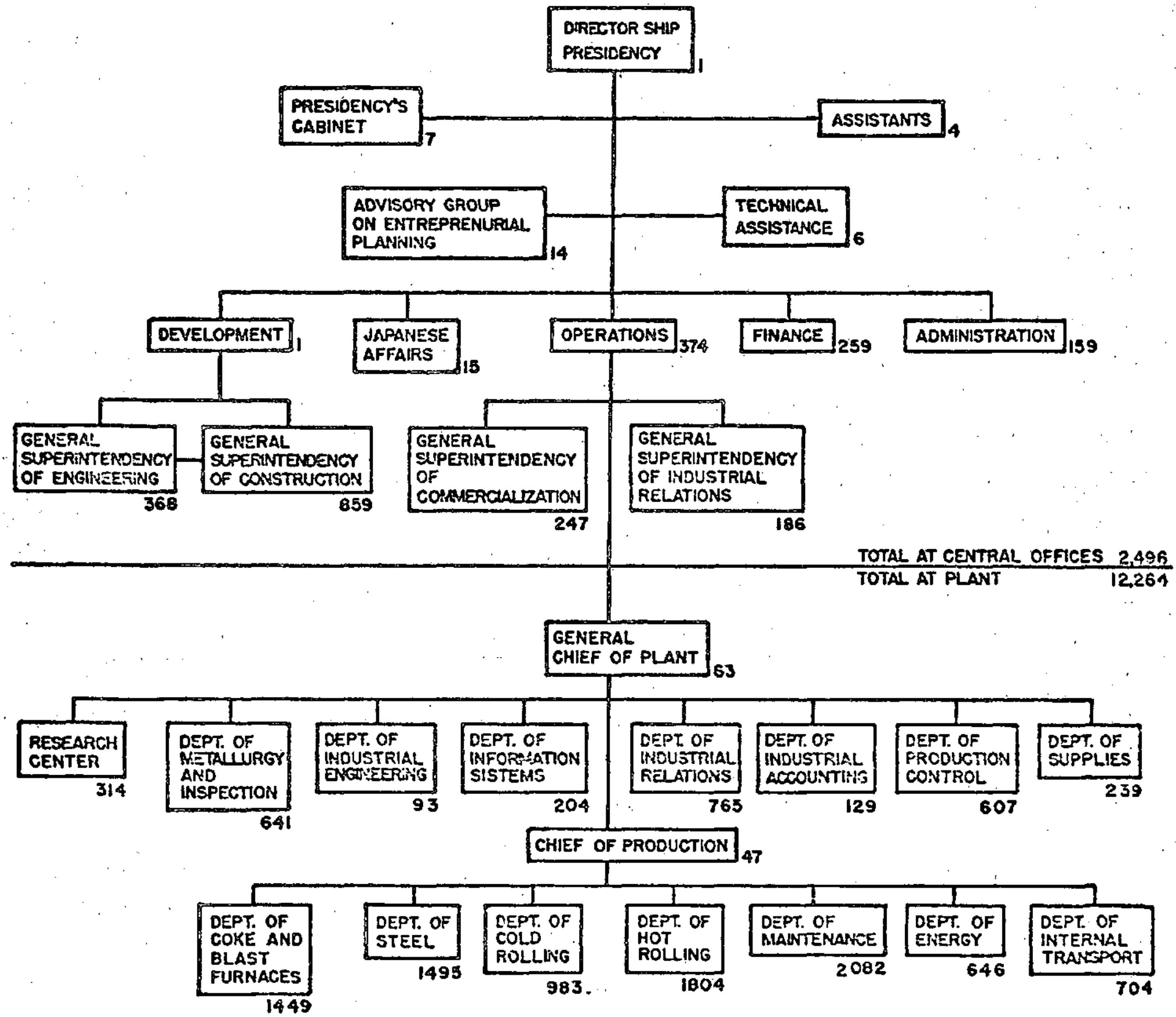
gineering which is responsible for coordinating and preparing the basic engineering for all the projects including layout, cost estimates, technical evaluations programing plans, etc. The third is that of Equipment Engineering which is responsible for all the preparation of all the detailed specification for the purchase or manufacture of the equipment units and the construction specifications including the structuring of equipment packages adequate for the capacity of national manufacturers and giving such manufacturers technical assistance. The fourth, Engineering Services is in charge of maintaining the system of cost control and progress reports. Finally that of Research and Information Processes is directly responsible for keeping the engineering group up to date or development in techniques and processes. It sets up and directs team studies in the research of processes or equipment specialized in steel production, acts as a link between the engineering department and the research center, and manages a special library of technical information and patents.(1) (2)

An idea of where the engineering section fits into the overall organizational structure of the firm and its relative size can be seen in figure 7.7. Unlike the various units which were discussed in section 7.2 which are part of the organizational structure actually at the plant site in Ipatinga, the Superintendency of Engineering is part of the organizational structure at the headquarters in Belo Horizonte. It represents 14.7% of the personnel in that structure.

(1) An interesting note from the point of view of the firms scan of the technological frontier is that as opposed to the more routine scan of technology information done by the CIT, this subdivision is more attuned to the frontier of newest developments. This group has a plant layout of every major steel firm in the world. Its mains sources of information on what other firms are doing is the annual reports of steel companies and of steel equipment manufacturer and equipment advertisements. Whenever they run accros something interersting they immedidately write away for it, to check whether it is of potential use for USIMINAS

(2) Information drawn from Luiz Eduardo Klinger Abreu , Op. Cit., pp. 300-320.

figure 7.7 ORGANIZATIONAL CHART OF USIMINAS 1978 (*)



* FIGURES REFER TO PERSONEL EMPLOYED JULY 31, 1978.
SOURCE - INFORMATION PROVIDED DIRECTLY BY FIRM.

7.4.4. The Third Expansion Plan and the Sale of Engineering Services.

For the third expansion plan[1], Amaro Lanari Junior, then president of USIMINAS, judging that USIMINAS had acquired enough experience, prohibited foreign participation in the engineering so the whole plan was done by USIMINAS personnel. Thus USIMINAS rapidly evolved from complete dependence on foreign (Japanese) technical assistance for the engineering work for the original plant and the first expansion plan to independence in the third expansion plan, which was started less than 15 years after the start of operations of the company. Further evidence of how much USIMINAS has developed in terms of engineering capacity is the fact that it is now providing much the same type of assistance which it initially received from the Japanes to the AÇOMINAS steel plant which is to start production in 1980 with a capacity of two million tons. The technical contract for technical assistance to AÇOMINAS forsees the utilization of 400,000 man/hours distributed accros 14 sub projects over a 10 month period with further assistance until the start up of the plant in 1980. Among the subprojects are plant planning, basic specifications, buying, dealing with equipment suppliers, approval of designs and documents, and technical assistance during equipment fabrication, plant construction and start-up. A separate agreement was also signed to cover the financial area.

The rapid transformation from a purchaser to a seller of such engineering is truly remarkable and should be considereed as one of the main, if not the most important technological change in its tech-

(1) The equipment for this plan was estimated to cost U.S.$1.061 million dollars.

nological evolution. Each expansion plan involves an effort similar to that of building a new plant. It is hard to overemphasize what is required in terms of technical capacity and administrative abilities or what it allows in terms of integrating the experience gained in operation under specific Brazilian conditions to the search for, selection, and adaptation of the most appropriate technology for such conditions.

7.5. Investment in Training

As one of the main elements in its technological strategy USIMINAS has emphasized the training of its personnel. The information we have on training is presented in figure 7.8. Unfortunately, it only covers the most recent years, and we do not have much detail. We would like to draw attention, to the 449 entries for persons trained abroad during the eight year period for which we have information. Presumably, those are higher level persons who have gone abroad for specialized and advanced training. Notice too that during the last four years the average cost person has been around half a million cruzeiros.

Figure 7.8.

Investment in Training Human Resources

	1969	1970	1972	1972	1973	1974	1975	1976
Number of trainees in Brazil	-	4,862	-	21,414	20,462	17,673	15,287	42,617
Millions of Cruzeiros	-	1,0		8,2	9,4	18,4	24,6	60,0
Number of Trainees Abroad	30	33	25	39	42	62	142	76
Million of Cruzeiros				9	20	28	83	53

Sources: 1969 - 1971 - Company Annual Reports

1972 - 1976 - Cota "Alguns Aspectos da Contribuição da USIMINAS para o Desenvolvimento Nacional" USIMINAS REVISTA Ano 8 nº 16 (Julho, 1976) p.84

Figure 7.9 "USIMINAS DISTRIBUTION OF TRAINING 1973-1977"

	1973			1974			1975			1976			1977		
	Total	InPlant	Outside	Total	InPlant	Outside	Total	InPlant	Outside	Total	InPlant	Outside	Total	InPlant	Outside
A. Production	14025	12623	1402	12815	11399	1416.	9550	8594	956	30373	23335	3038	26687	23712	2975
1. Skilled Workers	9414	8473	941	7159	6443	716	6135	5521	614	20695	18625	2070		na	
2. Middle Level Technicians and Technical Assistants	2974	2677	297	4012	3476	536	2193	1963	220	6775	6097	678		na	
3. Supervisory Personel	1637	1473	164	1644	1480	164	1222	1110	122	2903	2613	290		na	
B. Administration Services and Support	6234	5610	624	4597	3283	1314	5239	3696	1543	11959	9884	2075	9814	7769	2045
1. Staff	2436	2192	244							4630	3978	652		na	
2. Middle Level Management				1688	1229	459	2228	1721	507						
(2. and 3.)	2235	2011	224												
3. High Level Management				507	320	187	820	374	446	832	467	365		na	
4. Higher Educational Level other than in Supervision or Management Positions	1552	1397	155	2089	1422	667	1875	1300	575	6262	5207	1055		na	
5. Teaching Personel in General	11	10	1	9	8	1	148	133	15	27	24	3		na	
6. Student Trainees	-	-	-	304	304	0	168	168	0	208	208	0		na	
Total Number of Persons Trained	20259	18233	2026	1714	14682	2730	14789	12290	2499	42332	37219	5113	36501	31481	5019
Total Employees in USIMINAS	8422			9692			11207			12940			13821		
Av. No. of Courses Per Employee	2.4			1.8			1.3			3.3			2.6		

Figure 7.9 dissaggregates the types of training[1] by various skill levels and whether it was received inside or outside the enterprise. Roughly two thirds of the training is concentrated on people directly rélated do production (with the bulk of the training focusing on skilled production workers) and one third on administrative service and support personnel. Overall 85-90% of the total training is done inside the firm although the proportion trained in the plant is somewhat lower for administrative, service and support personnel. Notice that among the latter grouping roughly one quarter to one half of the training is as the higher educational level.

Figure 7.10 gives a quick overview of the educational composition of the labor force which helps to see some of

Figure 7.10

QUALIFICATION OF USIMINAS EMPLOYEES 1973-1977

	1973	1974	1975	1976	1977
	(%)	(%)	(%)	(%)	(%)
Higher Education	932 (11.1)	997(10.3)	1120(10.0)	1387(10.7)	1547(11.2)
Technical Level	1005 (11.9)	1263(13.0)	1487(13.3)	2718(21.0)	3126(22.6)
Skilled Labor	6461 (76.7)	7410(76.5)	8580(76.6)	8815(68.1)	9130(66.1)
Non Skilled Labor	24 (0.3)	22(0.2)	20(0.2)	20 (0.2)	18(0.1)
TOTAL	8822	9692	11207	12940	13821

(1) The total figures do not match those in figure 7.6 because the latter includes training of youngsters through SENAI which is not included in the numbers given in figure 7.7.

the results of the training programs.

Although the percentage of employees with higher education has been maintained more or less constant at around 11% of the total in spite of an increase of total employment of 57% over the period 1973-1977, the percentage of employees with a technical level has continually increase from close to twelve percent to slighly over 22% over the same period. As a result the number of employees with higher or technical educational has increased from 23% to almost 34% of the total over the past five years.

In large part these results can be attributed to the massive training programs although it is also possible that it may have been accomplished by hiring more qualified personnel. Figure 7.11 shows the evolution of turn over and labor force growth over the period. The high admission figures, particularly since 1971 help to explain in part why the firm has so many training courses. Most hiring is of young people with little previous experience.

Figure 7.11

USIMINAS TURNOVER AND LABOR FORCE GROWTH

Y E A R	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977
Admissions	4.9	4.8	14.3	24.6	27.2	42.6	48.1 1/	33.5	29.8	19.4
Demissions	10.0	5.9	15.2	23.1	23.7	17.5	34.4	19.4	15.8	12.8 (2)
Net Growth	-5.2	-1.1	-0.9	1.5	3.5	25.1	13.7	14.8	14.0	6.5

(1) This was unusally large because an expansion from nearly ACESITA and various manufacturing firms lured away a large proportion of the workers.

(2) Close to 80% of the turnover is in the skilled and non skilled group. Among the high administrative and engineers which total about one thousand USIMINAS only loses about 5% per year.

Over the last five years the percentage of total employees aged 25 and less had increased from around 38% to close to 45%.

Recently USIMINAS signed with the Federal University of Minas Gerais a contract for training 12 professionals for its research Center at the masters level. The program is estimated to cost USIMINAS U.S. $ 1,650,000. Besides showing the advancement of post graduate technical education in Brazil this contract also shows a significant new approach. The thesis topics are to focus on real production problems and in a sense could be classified as development of applied technology. This greater integration between the firm and the University is expected to bring benefits to both-more academic objectivity to the work carried on in USIMINAS, and closer touch with real world problems for the university.

7.6. Technology Contracts

In addition to formal and informal courses, another way in which USIMINAS has raised the technical capacity of its personnel is through technical assistance contracts. By focusing on specific problems these provide an excellent practical learning experience which the firm has utilized very successfully

Based on data presented in a thesis on the importation of technology by Brazilian steel enterprises(1) we know that between 1965 and 1975 USIMINAS received approval for 190 contracts. The total pay-

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(1) The thesis is based on the technology contracts registered with the Central Bank of Brazil between April 1965 and March, 1975. During that period 217 variable payment contracts and 517 fixed payment contracts were registered between 31 Brazilian steel firms and 300 technology selling firms representing 20 countries. Information was not available for variable payments, but fixed payments totalling U.S. $ 116.3 million were authorized under the codes technical services, technical assistance and patents, and trademarks and patents. Both the number of contracts and the payment have shown an almost exponential increase over the period which is greater then the dramatic increase in Brazilian steel production.81.3% of the contracts and 72.8% of the non-variable payments were for technical services. Technical assistance and patents accounted for 18.3% of the contracts and 21.7 % of the value. There were only 3 trademarks and patents, but they represented 5.6 % of the non-variable payments. The main supplying countries were: Japan, 50% of of the value, 24% of the contracts; USA, 29% of the value, 38% of the contracts; and West Germany, 13% of the value and 22% of the contracts. While the Japanese contracts supplied technology almost exclusively to the state firms, the U.S. contracts supplied both the private and the state firms, and West Germany was the largest supplier of the private firms.70.4% of the contracts and 93.1 % of the non-variable payments were made by the 8 state-owned firms. USIMINAS signed the most contracts (25.4%) and made the most payments (28.0) followed by CSN (16.8% of the contracts) and then by COSIPA (10.9%).although COSIPA paid more (27.4%) than CSN (20.4%) and,in fact, had the highest average payment per contract. Given the similarity in their technological profile and the fact that only a few firms have been responsible for the majority of the contracts it has been suggested these state-owned firms may have each bought the same technology package in some cases.

See Eduardo Galvão Moura Jardim, "Importação de Tecnologia pelas Empresas Siderúrgicas: Uma Análise com Base nos Registros do Banco Central do Brasil no Período de Abril de 1965 a Março de 1975." Masters of Science Thesis Submitted to the Postgraduate Program in Engineering of the Federal University of Rio de Janeiro,Brazil February 1977.

ments for these contracts could not be determined because they included 13 variable payment contracts for which there was no financial information. . However, for the fixed payment contracts, slightly over U.S.$ 32.5 million dollars were authorized. These were distributed as indicated in Figure 7.12. Note that there is a strong upward trend which coincided with the expansion plans, and that it does not include all the contracts since March 1975.

Figure 7.12

TECHNOLOGY CONTRACTS

April 1965-March 1975

	Number of Contracts		Payments Authorized (U.S. Dollars)
	Total	Variable	
1965 (1)	10	6	6,257,663
1966	6	1	54,030
1967	4	2	36,575
1968	5	1	200,666
1969	9	2	821,572
1970	10	1	3,209,257
1971	22	-	1,098,946
1972	13	-	6,502,975
1973	48	-	3,870,387
1974	52	-	8,670,307
1975 (2)	11	-	1,762,247
Total	190	13	32,564,620

(1) APR-DEC.

(2) JAN-MAR.

Source: Jardim, Op Cit, Annexes 12 and 13

We have been able to compile a list of the 18 main technology suppliers, during this period which is presented in figure 7.13. Although it covers only 58.9% of the contracts, they account for 94.6% of the payments. The Japanese strongly predominate, accounting for 75 of the contracts and 73.9% of total payments. They are followed by the Germans with 20 contracts and 16.2% of the payments and then by the U.S. with 17 contracts and only 3.8% of the payments. Notice the strong concentration in the supplying firms in that the three main ones supplied 52 of the contracts amounting to 69.7 % of the payments.

In terms of specific contracts one of the most, if not the most important was a ten year general assistance contract which USIMINAS signed with Nippon Steel(1). This contract was signed at the time the Japanese had finished their original free technical assistance package and had turned operational control of the firm over to the Brazilians.(2) The contract was primarily for the manufacture and standard operation control of a series of products of specified grades listed in figure 7.14 The assistance included guidance on rolling operations, process control on and after the rolling process, and maintenance.(3) The assistance involved both the dispatch of Nippon Steel personnel to USIMINAS and the training of USIMINAS personnel at Nippon Steel Plants in Japan.(4) USIMINAS could ask for up to 10 persons from Nippon Steel per year for no longer than six months per person for technical assistance for strip

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(1) The contract was actually signed with the Yawata Iron and Steel Co which became Nippon Steel after a merger with the latter in the early 1970's. However we shall always refer to the contract as one between Nippon Steel and USIMINAS.

(2) See sections 3.2 and 7.1.

(3) Standard operation control included oil injection in the blast furnaces; component range, oxidation, ingot mold, teeming, and component aim in the LD. Converters; and rolling schedule, ingot weight, slab weight, rolling temperature, and supersonic tests in the rolling section.

(4) USIMINAS could send to Nippon Steel up to eight persons per year for training in strip and plate products and up to four per year for training in operation control provided none stayed for more than six months.

Figure 7.15

USIMINAS: MAIN TECHNOLOGY SUPPLIERS

COMPANY	Number of Contracts Total	Variable	Payments Authorized
Nippon Steel	21	1	8,591,979
Nippon USIMINAS Co.	12	3	9,828,602
Isikawajima Harima Hearvy Ind.Co	9	-	1,999,602
Sankiu Transportatton Engineering	2		997,185
Mitsubishi Co.	5		658,500
Okura-Trading Co	1		32,564
Kawasaki Heavy Ind.	3		103.264
Kobe Steel Ltd.	10	1	493,868
Hitachi Ship Building Co	1		493,360
Mitsubishi Heavy Industries	3		215,631
Mitsubishi Shojikaisha Ltd	1		17,113
UBE Ind. Ltd.	4		322,936
Yawata Iron Co.	3	1	310,000
Sub-total Japan	75	6	24,064,604
USS ENGINEERS Consultants	3	-	496,600
BOOZ Allen Hamilton	6	2	582,500
BATELLE	8	-	185,406
Sub-total U.S.	17	2	1,264,506
Gutte Hoffnungs Hutte Sterkgrade	19	1	4,282,186
Mannesmann Meer Aktien-Gesselschaft	1	-	1,000,650
Sub-Total Germany	20	1	5,282,836
Sub-total identified in the list	112	9	30.813,287
Total	190	17	32,564,620

Source: Jardim , Op Cit; Computed from illustration nº 19 and plate products and for up to 6 persons per year under the same six month limitation for technical assistance in operation control. This scheme gave USIMINAS great flexibility in adapting the technical assistance to the various needs or problems which arose since it could routinely change the speciality of the Japanese consultants brought in.(1)

The fruits of the contract were felt very soon particularly in terms of the introduction of new products and improvement in quality which was very important given the depressed market of the period. In the second semmester of 1966 USIMINAS was already manufacturing new products under guidance from Nippon Steel. By August for example, it was producing killed steel with aluminum for deep-stamping and resistance to ageing for the automobile industry.(2) By September it began manufacturing steels for high pressure pipes(3) and steel with high resistance to traction and good solderability,(4). In 1969 it also introduced a new steel(5)

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(1) Overall the contract was very favorable for USIMINAS. It involved a fixed annual payment by USIMINAS for each of the 10 years plus a variable payment based on annual output for the last 5 years of the contract's duration. USIMINAS also had to pay travel, living, and foregone Japanese salaries to the Japanese technicians dispatched to provide the assistance. USIMINAS, however, could not transfer the technology to third parties. It could export any where except Asia in which case it would have to receive written permission to do so. Improvement and inventions made by either party and covered under the scope of the agreement would be available to the other party free of charge and in the case of patenting by one party the other would have non-exclusive right in Brazil.

(2) By 1969 which was the first year the car and truck manufactuerers bought more Brazilian than imported steel USIMINAS supplied 45% of the domestic steel.

(3) Series API 5LX-46 thick plates;5LX-52 Hot Strips

(4) SAR 50 and 55 in thick sheets and hot strips, respectively.

(5) SAC-50

Figure 7.14

Grades of Steel Products Covered by the 10 year Technical Assistance Contract

		Products	Grades
Sheets and Strip	a)	Hot and cold rolled carbon steel sheets and strip	SPN 1-5; SPC 1, 2 SAE 1006 - 1025 ASTM A415, 425 SA 32, 38, 41, 45 and their equivalents
	b)	Steel sheets and strip for deep-drawing	SPC 3; SPK; SPKD; SSPD and their equivalents
	c)	Steel sheets and strip for porcelain enameling	Ⓢ pure iron (equivalent to Armco iron) ASTM A424 and their equivalents
	d)	High-strength steel sheets and strip for welded structures	SM 41, 50; WT 50, 55, 60H ASTM A373; YES 36, 40; YAWTEN 50 and their equivalents
	e)	Hot rolled steel strip for line pipe based on API Specification	API-5LX 42, 46, 52, 60 and their equivalents
Plates	a)	Steel plates for general structures	SS34, 41, 50; ASTM A-7, 36 (A,B,C,D) ASTM A-113 (A,B,C); ASTM A-283A and their equivalents
	b)	Steel plates for hull construction	Unified Requirement A, B, C, D, E and their equivalents
	c)	Rolled steel plates for boilers	ASTM A201-A, B; ASTM A-285-A, B, C ASTM A-30 and their equivalents
	d)	High-strength steel plates for welded structures	SM 41, 50; WT 50, 55, 60H ASTM A373; YES 36, 40 YAWTEN 50 and their equivalents
	e)	Steel plates for line pipe based on API Specification	API-5LX 42, 46, 52, 60 and their equivalents

Note: The "equivalents" as referred to in the above table shall mean those products based on other widely accepted standards than those specified in the above table and considered to be equivalent to those standards.

Source: Information provided directly by Company September, 1978 which was the only one in Brazil specified for wagons.

In 1970 it developed and or began producing eleven new types of steel in order to attend market demands. By that year it supplied 93% of all Brazilian Steel used in the shipping industry 52% of that used in the auto industry and 51% of that used in the railroad industry. Figure 7.15 summarizes some of the main steels introduced since 1970. Despite the different nomenclatures many of them were those covered under the technical agreement. Notice too how much of a price premium the majority of them involve[3]

Due to the success of the original contract, when it expired in April 1976, USIMINAS worked out a second contract with Nippon Steel[1]. Although this time the contract just for five years it is structured very much like the original contract. The main difference is that the new contract covers about 7 times as many steel products and grades as well as 57 specific technologies covering ten areas of operative technology; integrated metallurgical control; maintenance; production planning and control; testing and analysis; product applications, and antipollution technology. Overall it is more specific and covers much more than the previous contract, showing that USIMINAS has learned how to ask for more[2].

(1) Nippon Steel is the worlds largest steel producer (1976 production was 25M.t) USIMINAS was its first venture outside of Japan. Since then Nippon Steel has made 221 technical assistance contracts in 32 countries. Fourty four percent of the contracts have been in developed countries. See Makoto Okaki, "Idea basica y practicas de cooperacion para el establecimiento de plantas siderurgicas integradas en paises en desarollo". Siderurgia Latino Americana Nº 212 (Diciembre 1977) pp. 60-70.

(2) Unlike the original contract the new one requires the payment of a fixed lump sum rather than a combination of fixed and variable payments. It provides for 72 man months of technican assistance from Nippon Steel personnel and the training of 40 man months of USIMINAS personnel at Nippon Steel and in all cases the maximum amount of time per person has been reduced. There is no export restriction, and the restriction or non-disclosure to third parties has been reduced to five year after USIMINAS' receipt of the information. The treatment of improvements and invention is completely symetrical.

(3) Appendix VI gives a graphical idea of the introduction of new products

Figure 7.15 NEW STEEL PRODUCTS AND QUALITIES INTRODUCED BY USIMINAS 1971-1977

APPLICATIONS	Type of Product	QUALITY	Start of Manufacture	Orders Accepted 1rst Semmester 1978	% Increase In Price
High strength weldable structural steel (for application in general structures, machines, bridges, buildings, ships, cranes, agricultural tools, wagons, pressure vessels, oil tanks, etc.)	PLATES	NTU-CG-SAR-50-B	1972	0,13	21,8
		NTU-CG-SAR-60R-A e B	1974	0,36	35,7
	HOT STRIPS	ASTM-A-572-60	1972	0,01	26,3
		ASTM-A-607-50,50-EEP	1973	0,34	26,3
		NTU-FQ-SAR-60R-A e B	1974	0,45	35,4
High strength weldable structural steel resistant to atmospheric corrosion (for application in buildings, civil construction work, wagons, agricultural tools, ships, mining equipment)	PLATES	NTU-CG-SAC-50-II-A,B,C	1971	0,66	35,7
	HOT STRIPS	NTU-Q-SAC-50-II-A,B,C	1971	0,32	35,4
		ASTM-A-242-II	1974	0,17	35,4
Floor Sheets	PLATES	NTU-CG-USIPISO	1974	0,65	36,3
	HOT STRIPS	NTU-FQ-USIPISO	1974	0,35	36,3
High resistance shipbuilding steel	PLATES	NAVAL-AH-32	1972	0,03	23,7
		NAVAL-AH-36	1972	0,14	26,4
		LR-AH-34 S	1976	0,60	23,7
Piping and Tubing steel (for application in general conductors)	PLATES	API-5LX-X52	1971	0,30	23,7
Shipbuilding structural steel (for application in ships' structures)	HOT STRIPS	GL-A	1977	0,42	11,5
Steels for liquified petroleum containers	HOT STRIPS	ABNT-EB-253	1973	1,51	9,9
Steels for the automobile industry (for use in beams, chassis, wheel rims and habs, etc.)	HOT STRIPS	ABNT-EB-593-LN-20	1973	0,20	9,9
Electromagnetic quality (for use in motors for refrigerators, small generators, magnets, motors for electrodomestics, small alternating current motors, direct current motors, relays, pole pieces, etc.)	COLD STRIPS	NTU-USICORE-360	1974	0,14	50,8

Source: Information supplied directly by the company, September, 1978

Another contract signed with Nippon Steel was for the specification of the equipment for the research center and training of the research staff covering the period 1970-1975[1]. USIMINAS is currently negotiating another five year contract with Nippon Steel oriented more to advanced training of the research staff. In 1972 a special contract was signed with Nippon Steel for the training of personnel and star-up of the new continous cold strip mill which among other things involved sending 12 engineers, technicians and operators to Japan for training. Note too that Nippon Steel was contracted fo supply the engineering for the second expansion plan.

In 1972 a contract was also signed with United States Steel Engineers and Consultants for the area of industrial engineering. It should also be remmembered that one of the first contracts signed by USIMINAS was for the study of administrative structure and reform with BAHINT which lead to the administrative reform and the introduction of the standard cost system which was very important for the firm. It is interesting to note that the contracts with the U.S. have been with consulting, engineering or research firms rather than with steel companies or equipment suppliers as is more common in the case of Japan and Germany.

With respect to Germany, the contracts with Guttehoffnungs Hutte Sterkgrade seem to have been more related to technical assistance for the equipment supplied by that firm, although we know that one of the contracts was for assistance in the development of the use of steel structures in civil engineering work as part of the product diversification strategy behind the creation of USIMEC. The Mannesmann contract was probably related to the technical assistance with continous casting.

(1) During this period 13 persons were trained at Nippon Steel.

In summary, the basic strategy behind its technology contracts has been to have a general contract to cover product development and standard operational control, and to contract for specific technical assistance in various specialized areas as the needs arise. This has enabled USIMINAS to have a certain degree of integration in its basic technology while at the same time providing flexibility for eventual problems. It also seems that when USIMINAS contracts for assistance in a specialized area such as dinamiting of scaffold formed inside a blast furnace it takes measures to insure that its own personnel carefully accompany and participate in the operation as much as possible so that it can solve the problem on its own the second time it comes around. In that way as it absorbs what it pays for it is able to continually push back the frontier of the technical assistance it purchases to more advanced and specific areas.

7.7. Summary of Investments in Technology

A more dissagregated though less comprehensive view of USIMINAS' investments in technology is given in figure 7.16.

Figure 7.16

USIMINAS INVESTMENTS IN TECHNOLOGY THOUGH 1976

	1.000s of dollars	Percentage
a) Personnel training abroad	2.000	6.5
b) Personnel training in the firm	10.000	32.5
c) Manufacturing licenses	1.800	5.8
d) Technical assistance to production	4.900	15.9
e) Engineering consulting	5.000	16.2
f) Administrative consulting	1.480	4.8
g) Research consulting	1.360	4.4
h) Research laboratory and equipment	4.270	13.8
	30.810	99.9

a) This represents expenses incurred in sending 380 specialists (243 of higher level, 137 middle level) abroad for traineships or courses lasting between 3 and 24 months during the period 1966-1976. Besides these, numerous technical visits were made and various technical congresses were attendend.

b) Training in Brazil includes training within the firm as well as training in other institutions. The ten million figure is the approximate dollar equivalent of costs incurred in training just the persons within the firm over the period 1966-1976.

c) Refers to patents and licenses for manufacturing of steel products.

d) Refers to consulting services for metallurgincal control and operation problems related to the manufacturing process.

e) Includes expenses undertaken with consulting and or development of engineering projects for expansion of the plant.

f) Embodies all outlays on consulting for administrative reform, computers, and information.

g) Includes all payments to foreign inst tions in consulting and planning, and technical preparation of the personnel for the sep-up of the research center.

h) Refers to the costs of the research center and its equipment. See section 2.4 for more details. Besides this equipment, there are laboratories for metallurgical control and inspection covering physical and chemical tests. In 1976, these laboratories had four X-ray spectrometers, various equipment for instrumental chemical analysis, mechanical analysis and thermic treatment. Unfortunately, no cost estimate was available.

Source: COTA, "Investimentos ..." p. 32-33.

In should be noted that the list is not complete in that categories c-g and sum to 14.5 million dollars whereas, as was seen above, slightly over 32.5 million dollars for technical assistance had been approved between April 1965 and March 1975. Part of the discrepancy may lie in that the latter figure includes technical assistance for mounting and start-up of equipment which does not seem to be included in the list dissagregated by type of investment. Adding in the 18 million dollar difference the total investment in technology is close to 50 million dollars. Almost 25% of that total was spent training personnel apart from the research center staff. The research center and the consulting services to set it up accounted for nearly 11% of the total.

All of the costs mentioned so far represent investment of one sort of another in the technological infrastructure. It should be emphasized that it does not includ any operating costs, for which we could not obtain any information. The main point to be made is that USIMINAS has invested a lot in creating its technological infrastructure. Due to the lack of detailed data we cannot attempt any estimates of the relative returns to the different types of investments.[1] However, our impression, given USIMINAS dramatic technological performance is that they have paid off handsomely. What we hope to have made clear, however is that the absorption of foreign technology in order to develop and adapt it to specific domestic needs and to eventually be in position to create technology requires an active participation of the domestic partner and significant investments in the preparation of its human resources and its organizational structure.

(1) Lanari, states that until 1975 USIMINAS invested close to 15 million dollars in its technological development contracts and to give an idea of the return he points out that just the improvement of the yield of cold rolled sheets between 1966 and 1975 was worth 15 million dollars. (USIMINAS Relatório Anual 1975,p.5)

CHAPTER EIGHT

8. SUMMARY AND CONCLUSIONS

8.1. Type and Nature of Technical Change

The objectives of technical change encountered in this case study have encompassed the whole range from cost reduction to production increase to product diversification(including quality improvement) and to changes in imput type and mix.

As developed in section 5.3. and detailed in sections 6.2, one of the overriding concerns during the first ten years of operation of the firm was cost reducing technical change through capacity stretching of the original equipment. During this period there was virtually no new investment. What little investment occurred was is small peripheral equipment such as sintering screens roll crushers, minor modifications in major equipment units, etc. Technical change was thus of the disembodied type in terms of the definition developed in chapter four.

Although most of technical change which occurred during this period depended on and indeed was in function of an expansion in production, it did not depend on scale multiplying plant expansions but on capacity stretching of the existing plant. As detailed in section 6.3 and explained in the context of the raw material and capital dominated nature of steel production pointed out in sections 4.2 and 6.5, such capacity stretching was achieved mostly through better selection and control of the physical - chemical properties and preparation of the raw materials (particularly in the sinter and blast furnace sections) and of the better utilization of the existing equipment units through changes in operational methods or useful volume (blast furnace and steel sections). The problems with raw materials and their variations in quality (which was something beyond the firms control) conditioned the technical change path and forced the firm to develop a whole series of homogenization and uniformization measures in its raw materials receiving and preparation yard which were crucial for the improvement of the whole operation of the firm since steel production is a multistage process. For that reason, changes such as those which led to an increase in the capacity of the sinterization and blast furnace sections have repercussions on the steel section and create pressure for internal changes there which focus attention on increasing capacity, and vice versa.

Although it was not possible to explicitly quantify any saturation effects there was evidence of such effects particularly in the case of the steel shop and blast furnaces. As was pointed out, however, in several occasions it was possible to overcome these effects by the use of auxiliary technologies such as the three channel oxygen lance in the case of the steel shop; and fuel injection and oxygen enrichment in that of the blast furnaces. All three are examples of how important external technological developments can sometimes be grafted on to older vintage equipment and in that way improve it.

Even though no meaningfull cost - benefit type comparison could be made between the cost and returns to technical change realized within the plant versus those due to the utilization of technology embodied in new equipment units because of the lack of cost data dissagregated by equipment units, it would seem that the former would compare quite favorably with the latter, at least over limited scales.

Because the crisis seriously affected the operation of both new and old units and led to their subutilization no detailed attempt could be made to separate out how much of the production increase had been achieved by endogenous improvements as opposed to increases achieved with installation of new units. Very roughly however it could be calculated that the 700,000 ton increase from initial nominal capacity to production of 1,200,000 with the same equipment was an internal contribution whereas the expansion from 1.2 Mt to the current production of 3 Mt was external.

This would credit internal technical change efforts with 39% (7/18) of the production increase but it abstracts from the costs. It should also be noted that to some extent the expansion itself embodied some of the internal learning since such learning and operational experience was utilized in making the choice and specifications for the expansion plan.

As developed in section 6.4 the possibility of undertaking a large expansion plan permitted the firm to adopt new technologies which were embodied in capital equipment such as the larger size blast furnace and all its embodied advances, larger oxygen converters, continous casting, and production of wide plates. It is important to emphasize that such capital embodied technical changes were quite firmly tied to scale multiplying plant expansion for it is hard to imagine that they could have been introduced at the expense of scrapping the existing equipment which was operating very efficiently. This implies that capital embodied type expansions will usually be closely linked to the scale of the units involved, the size and rate of growth of market demand and the degree to which various disembodied technical changes can be adopted by existing equipment which may prolong their useful life.

8.2. The Technological Strategy of the Firm and Conditioning Factors

Chapter three explained how the creation of USIMINAS was the result of the joint interest of the State of Minas and the Japanese. Minas produced practically all the iron ore in Brazil and wanted its own integrated steel plant but lacked the technology and the capital for such a venture. The Japanese wanted a show-case for their technology as a sales strategy for their steel equipment and know how. The Japanese Government helped organize the private groups in order to not only supply equipment but also to participate in the capital stock and provide technological assistance to insure that it would be indeed a showcase.

Initially the Japanese were in charge of operational control and the administrative structure of the firm. While the results in the first area were good there were serious problems in the later because of the difficulty of transplanting the administrative structure for a large plant to a smaller one in a different socioeconomic and cultural context. However as this problem was quickly identified the Brazilians took measures to change the administrative structure, This was accomplished by 1966 when the Brazilians had acquired the technical capacity to run the plant themselves thanks to the training received from the Japanese.

The changeover of operational responsibility occurred in the midst of a Brazilian steel market crisis and of a continuing financial crisis of the company. The only way for the company to break-even was to expand output to at least one million tons per year. However because of the market crisis and because of its poor financial shape it was not able to obtain financing for the expansion. This forced it to stretch the capacity of its original equipment in order to get a better capital output ratio . Such capacity stretching was possible thanks to the implementation ofa standard cost system with an elaborate organizational infrastructure to study its existing equipment, compare it to the best world performance, and then try to reach the same or higher levels.

The preocupation at this stage, now that the basic operation of the plant had been mastered, was to move beyond the cook book phase to study what was behind the recipe. The implantation of the standard cost system was a way to break the recipe to its basic elements and to study them independently and how they fitted together. Each element and the parts it formed were then compared with those used elsewhere in order to learn where USIMINAS was weak and where progress could be made. This required and expansion and specialization of the support structure including computer services to compile internal statistics and the development of an information organ which could search for and collect technological information external to the firm.

The brazilians were carefully studying the advantages and dissadvantages of their own equipment no from just what the manufacturers had suggested, but from their own experience and learning as wel. They began to modify and adapt the equipment, to increase thier control over the production process, and to streamline its operation in order to obtain the maximum performance from their initial plant.

As this stage developed a greater emphasis on technical support was necessary and this led to the the creation of the Research Center, to give support to the support structure. The Research Center was initially oriented 100% to technical support activities. Its implementation was gradual and it required an initial adaptation period. Lanari (1) has

(1) Lanari, "A Empresa Siderurgica..." p.13

suggested that the premature advance to this stage can often lead to failure if the operation sector is not yet well aware of the need for or usefulness of a well-developed support structure. Happily, the center succesfully weathered the initial adaptation phase and was able to develop a good working relationship with the operational sector as it gained its confidence.

In the early seventies when the market was once again booming and the Government was sponsoring and in fact subsidizing large capital intensive expansions, USIMINAS responded by proposing a large capital intensive expansion which would increase its capacity three fold in less than a decade. Also, in response to such massive expansion needs and the lack of sufficient national engineering capacity to meet those needs, USIMINAS reorganized its internal structure to develop its basic engineering.(1) By 1975 it was in a position to do all the engineering work for its third expansion plan.

Now, rather than buying mostly from the Japanese as was the case of the original plant and its first expansion USIMINAS is in a position to scan the whole technological frontier and to draw up its own specifications for what it wants to purchase. In addition it is able to provide engineering assistance to domestic capital goods producers as well as to other steel firms. It is doing for the new Açominas steel plant in Brasil basically the same thing which the Japanese did for it when it was getting started.

USIMINAS also spun off a subsidiary (USIMEC) which was initially launched as a way of diversifying production into large metal structures. With the development of a market for national capital goods producers as a result of the massive Government sponsored expansion plans USIMEC also entered that industry

(1) As revealed by the thinking behind the technological prism there was a growing concern for the necessary interrelationship between operation, research, engineering, and equipment manufacture, where the latter was closey tied in to the needs of expansion plans.

and has rapidly became one of the country's largest manufacturers.

To a large extent USIMINAS has been forced to develop because of the exogenous demands placed upon it. First the profitability problem in the context of a depressed market, its high debt sales ratio, and the inability to obtain finance forced it to develop its technological infrastructure in order to squeeze as much as possible out of its existing equipment. Then the boom in the market and the Government sponsored expansion plans forced it to develop its basic engineering and in that way enabled it to obtain a higher degree of technological independence. However, as is demonstrated by the poorer perfoımance of the other two large state owned firms in the flat products sector who were subject to more or less the same exogenous demands. a part of the credit must also be placed on factors internal to the firm. Although these are more difficult to identify it seems that they are related to the emphasis USIMINAS has given to the training of its personnel, to the use of technical assistance contracts as learning experiences, and to the long period that it was under one management which thus had a chance to implement a long range technical capacitation program.

Overall the USIMINAS experience suggests that successfull local technological development depends on a relative long term strategy of building systematically on experience as it is acquired.

The first phase of this process involved accepting the practices and advice given by the Japanese in the initial operation of the plant. However, as a clearer idea of the technological package was obtained through this initial experience and the firm passed to the stage of analysing the contents of the package it passed from the know how stage to the know why stage.

As it learned by doing, it entered into the more difficult phase of studying and understanding its technology in order to pinpoint its deficiences and corect them. This involved the purchase of a more specific and more focused technological assistance. USIMINAS absorbs the technology in purchases at each step so that it has progressively moved the type and nature of the assistance which it buys to a higher and more specific level .

By developing this internal technological capacity along with better information on what is currently happening in the technological frontier it is in a better possition to know how it can best acquire it and has become more technologically independent. This does not necessarily mean that it is buying less, but that it is buying more selectively and more efficiently what it can not itself do.

The next stage, toward which it now seems to be moving, is to go beyond importing and adapting technology to creating new techniques, new processes and new production In the Research Center emphasis is already being put on training personnel with a higher theoretical level and the center is already starting to take out important patents.

The evolution of USIMINAS thus shows a technological strategy which rather than seeking to resist foreign technology, as is currently advocate by many, has sought to pull itself up byit. USIMINAS started by being completely dependent on foreign technology and using that as a base from which to selectively absorb more advanced technology through which it has progressively developed its technological potential. From a technological dependent firm it had evolved to the point we where it is developing technology of its own and selling technical assistance both nationally and internationally. It is important to notice however, that this was achieved in a step by step process as part of a long term strategy which involved development of the human element and a complex organizational structure to provide the technical support for such progress. While it may be the exception rather than the rule it is an example of what is possible when the domestic partner pursues an active or even agressive technological strategy.

What stands out from this case study of USIMINAS is the tremendous amount of learning which has taken place. The measurement of such learning defies any conventional type learning curveapproach because it inucludes much more than cost reduction with existing equipment. As developed in section 7.4 it involves the learning in basic engineering which can affect the cost structures possible through expansion plans. It includes such externalities as the engineering assistance which the firm gives national equipment manufacturers through its expansions and the training it provides for Brazilian engineering firms and Brazilian workers in the firm. It also includes the flexibility to adapt to changing conditions which might have otherwise led to increasing costs or production stops. Also, and even more difficult to measure it is the basis of a change of attitude towards more self confidence and self relianee which are the basis for new indigenous technological developments.

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