The Expansion of the Alumina Industry: The Case of Venezuela

by

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SUBMITTED TO THE DEPARTMENT OF
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Abstract

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The objective of this thesis is to provide Corporación Venezolana de Guayana [CVG] with a decision-making framework to facilitate investment planning for the Venezuelan alumina industry. This framework of analysis reflects not only the importance of investing in an alumina project, but implies a strong relationship with possible development options either horizontally and/or vertically in the industry. The industry is analyzed from a global perspective, and its main determinants evaluated: capital costs, bauxite, energy, caustic soda, labor and alumina prices. This study further enumerates the factors affecting alumina pricing, and discusses two models, perfect competition and oligopoly, to describe the underlying behavior of the industry. A simulation model is presented, which considers a Net Present Value [NPV] approach from the equity-holders' perspective as an investment decision-rule, to appraise an alumina refinery with a capacity of one million tons per year in Venezuela.

To accomplish the proposed objective, important questions need to be discussed: (1) Is it worthwhile to undertake an alumina expansion project in Venezuela?; (2) what is the comparative advantage for Venezuela to invest in alumina?; (3) if Venezuela does not expand its domestic primary aluminum industry, can the Venezuelan alumina project compete internationally in the free market?; and (4) what risks and uncertainties are associated with investing in alumina refineries?

The study concludes that at this point, alumina capacity expansion in Venezuela is not recommended. If all non-linearities, option-characterized cash flows, such as subsidies, preferential financing, government guarantees, and tax exemptions are removed, the most likely scenario would result in a zero-NPV outcome. Further, the alumina industry is highly volatile and a risky business to enter. CVG should focus rather on exploiting the possibilities of expanding its primary aluminum capacity, where clear comparative advantages exist.

Thesis Supervisor: Paul Smoke
Assistant Professor of Political Economy and Planning.

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Introduction

The objective of this thesis is to provide Corporación Venezolana de Guayana [CVG][1] with a decision-making framework to facilitate investment planning for the Venezuelan alumina industry. This framework of analysis reflects not only the importance of investing in an alumina project, but implies a strong relationship with possible development options either horizontally and/or vertically in the industry[2]. The industry is analyzed from a global perspective, and its main determinants evaluated: capital costs, bauxite, energy, caustic soda, labor and alumina prices. This study further enumerates the factors affecting alumina pricing, and discusses two models, perfect competition and oligopoly, to describe the underlying behavior of the industry. A simulation model is presented, which considers a Net Present Value [NPV] approach from the equity-holders' perspective as an investment decision-rule, to appraise an alumina refinery with a capacity of one million tons per year in Venezuela.

To accomplish the proposed objective, important questions need to be discussed: (1) Is it worthwhile to undertake an alumina expansion project in Venezuela?; (2) what is the comparative advantage for Venezuela to invest in alumina?; (3) if Venezuela does not expand its domestic primary aluminum industry, can the Venezuelan alumina project compete internationally in the free market?; and (4) what risks and uncertainties are associated with investing in alumina refineries?

Alumina is the product of a bauxite refining process. Depending on quality, two to four tons of bauxite are required to produce one ton of alumina. All refineries use basically the same technology, but it should be modified to be appropriate to the bauxite type used in

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1 Corporación Venezolana de Guayana is a development corporation created in 1960 to manage the Guayana Region development.

2 "Horizontally" refers to further expansion within the alumina industry, and "vertically" refers to backward and/or forward integration into bauxite and/or primary aluminum, respectively.

the process. Bauxite from any given mine then, can be processed only by some of the refineries, and similarly, each refinery can use bauxite from only some of the mines. The refined bauxite or alumina, is then smelted to produce primary aluminum at a ratio of 1.95 tons of alumina per ton of primary aluminum. Further transformations are made to manufacture end-user products. This thesis will study the alumina refining stage and its relationship with bauxite and primary aluminum operations.

The Venezuelan alumina industry has an installed capacity of 1.4 million tons per year, and is currently expanding its capacity to reach two million tons per year by the end of 1990. The target of Venezuelan policy makers is to have a balanced and fully integrated aluminum sector[3] capable of mining eight million tons per year of bauxite, refining four million tons per year of alumina, and smelting two million tons per year of primary aluminum.

The search for economic and social progress involves making the most rational use of limited resources, such as management, capital, foreign exchange, and natural resources. Individual investment proposals in the aluminum sector must always be evaluated in accordance with a coherent set of policies which define the objectives for each industry in the sector. Planning and evaluation of capital investments in alumina refining, are increasingly complicated because of sudden changes in the price of resources, output price volatility, government intervention, and new technological developments. Further, aluminum sector projects often require large initial capital outlays, long lead time, and time lags between initial investment and future returns.

The alumina market is characterized by high volatility and has no reference cycle, as that found in primary aluminum or other products. Alumina transactions are, for those firms outside integrated systems, primarily contractual arrangements with few spot

[3] The aluminum sector is that sector which contains the bauxite, alumina and primary aluminum industries.

transactions. In 1989, only about 5% of free-market sales were in the spot market.[4] Given time delays for alumina prices to adjust to new conditions as a result of its contractual market nature, contract price oscillation tends to increase. Factors that might provoke alumina prices to oscillate are primary aluminum prices, supply and demand balance in the free-market alumina, changes in productive capacity, and different contractual agreements among the concerned parties. To understand alumina's pricing response to these factors, it is necessary to understand the underlying industry organization. Two models are presented: perfect competition and oligopoly, assuming there is a price leader. Although it is beyond the scope of this thesis to demonstrate which of the two is the underlying organization of the industry, both are presented to shed some light on the issues that might be encountered by any firm when analyzing potential alumina capacity expansions, as is the case for CVG.

Modern finance theory provides a general equilibrium framework for the valuation of capital assets under uncertainty: the Capital Asset Pricing Model [CAPM].[5] Initially formulated in the context of perfect markets and a single holding period, it has been extended to cover multi-period projects.[6] The CAPM provides the theoretical foundations for the NPV decision-rule whose usefulness lies in pointing out the sources of economic value accruing to various agents involved in the project.

In evaluating capital investment decisions, in this case in the Venezuela's alumina industry, it is not sufficient to provide the decision-maker with a project appraisal alone. In order to make an intelligent decision, it is necessary to understand the factors affecting the environment in which the investment is to be undertaken, i.e., the economic situation of the country, the organization of the industry, the valuation model itself, and most important the sources of competitive advantage that justify the investment. Finally, it is important to

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4 Venalum C.A. data base.

5 To review the model, see Michael C. Jensen, "Capital Markets: Theory and Evidence", in The Bell Journal of Economics and Management Science, 3(2), (Autumn 1972): 357-398.

6 Eugene F. Fama, "Risk-Adjusted Discount Rates and Capital Budgeting Theory Under Uncertainty", Journal of Financial Economics, 5(1), (August 1977): 3-24.

answer the following question: if assuming perfect markets[7] where the expected NPV is zero, what are the sources of value that make the project's NPV greater than zero?

The study concludes that at this point, alumina capacity expansion in Venezuela is not recommended. If all non-linearities, option-characterized cash flows, such as subsidies, preferential financing, government guarantees, and tax exemptions are removed, the most likely scenario would result in a zero-NPV outcome. Further, the alumina industry is highly volatile and a risky business to enter. CVG should focus rather on exploiting the possibilities of expanding its primary aluminum capacity, where clear comparative advantages exist.

This thesis consists of seven chapters, organized as follows: Chapter 1 analyzes the alumina industry vis-a-vis Venezuela's current economic situation. This industry has changed dramatically since the energy shocks of the 1970's and 1980's, from a strong oligopoly since its beginnings in 1900, to a more segmented industry, which is now a quasi-competitive organization. This chapter also describes the Venezuelan aluminum sector, its strategy and future prospects. Chapter 2 analyzes the alumina industry from a global perspective. Chapter 3 examines issues concerning CVG-Aluminum's [CVG-AL][8] vertical integration policy and strategic planning. Although discussed at a general level, these issues are illustrative in defining an optimal investment plan. Chapter 4 analyzes the cost structure of the industry, and is divided into two main sections: capital costs, which focuses on analyzing the impact of the large initial capital outlays required for new greenfield projects[9], and operating costs, which focuses on the refinery's main operating cost determinants: bauxite, caustic soda, labor and energy. Chapter 5 studies the underlying organization of the alumina market and its behavior, analyzes the factors that affect alumina

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[7] A perfect market means the opportunity to undertake the project is available to all competitors, which is true in the case of the alumina industry.

[8] CVG-Aluminum is the organization within CVG in charge of the aluminum sector.

[9] Greenfield projects are new projects which require considerable investment in infrastructure. On the other hand, bronwfield projects are referred to as projects which use the infrastructure facilities already in place.

prices, and examines the impact of new capacity expansion on the industry. Chapter 6 then presents the valuation results for a Venezuelan alumina refinery plant, with the capacity of one million tons per year. The objective of this chapter is to provide a decision-making tool for strategic investment planning. Chapter 7 presents the conclusions and policy recommendations for the expansion of the Venezuelan alumina industry.

Chapter 1
General Background

Venezuela is currently going through a restructuring program at all levels. The target is the implementation of a set of policies that will provide the country with a coherent, sustainable development strategy. This chapter will provide background information on the aluminum industry, globally and in Venezuela, and the country's economic situation for the analysis of capital investments in the alumina industry. Alumina refining is one of the aluminum four-stage-production process, which also includes bauxite mining, primary aluminum smelting, and aluminum semi-fabricating and manufacturing.

1.1. The Aluminum Industry.

The organization of the aluminum industry has changed from a monopoly since its beginnings in 1900, to an oligopoly between World War II and the 1970's. Since then, the industry has been changing towards a more segmented, quasi-competitive organization. This pattern of evolution, typical of many mature industries, will be analyzed in this chapter, and the aluminum production process described.

1.1.1. Brief Historical Developments.

The development of the aluminum industry is divisible into three periods. Each period reflects changes both in the industry itself and the industry's focus on downstream operations as main source of revenue. Prior to World War II, the monopolistic nature of the industry in the United States was the dominant one globally. New entry and an oligopolistic structure characterized the immediate post-war years. Recently, there has been a new wave of independent entrants as a result of their access to low cost raw materials and energy resources. This increasing segmentation in the industry has led to a much more competitive organization.

The history of the aluminum industry is closely tied to its current organization. The degree of vertical integration necessary to compete in this industry changes as its organization changes. In its early periods during the late 19th and early 20th centuries, competitive suppliers of alumina and/or buyers of primary aluminum simply did not exist. This forced pioneer companies to integrate their operations. In the immediate post-World War II years, the advent of new entrants, as a consequence of Alcoa's divestiture, resulted in a opening of the arm-length alumina market[10].

The surplus alumina position[11] of pioneer companies, and because of the sudden increase in energy prices during the 1970's, permitted new entrants to enter the industry at the primary aluminum stage only. New primary smelters arose principally in areas with access to low-cost energy resources. Consequently, since then, a more segmented, quasi-competitive organization has characterized the industry.

This industry evolution is consistent with the general life-cycle theory of integration, i.e., that competitive markets can only become established when the market is large enough to support buyers and suppliers at a minimum efficient scale. When this stage is reached, vertical integration incentive declines, and the industry organization leads to a competitive environment.[12]

1.1.2. Aluminum Industry Production Process.

It is useful at this point to describe the primary aluminum production process and its derivative products. The production of aluminum involves a series of different processes

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10 An arm-length market is defined as the market where transactions are made between unrelated parties.

11 Long position is an available surplus for the free-market after covering internal requirements. Short position is defined as the dependence on the free-market to cover internal requirements.

12 Arnoldo C. Hax and Nicolás S. Majluf, Strategic Management: An Integrative Perspective, (New Jersey: Prentice-Hall, 1984), pp. 182-208, and Edward H. Forbes and Thomas J. Bate, II, "The Life Cycle Approach to Strategic Planning", unpublished master thesis, Sloan School of Management, Cambridge, MA., 1980.

that can be thought of as a vertical integrated production chain from upstream mining to downstream fabricated products.[13] Upstream, the industry's commercial history and available technology have been relatively invariant, allowing the chain of production to be broken into a set of well recognized and technically independent stages.

Each stage of production combines the output of the previous stage with an array of other goods and services, to produce the output for the next stage. Bauxite mines produce a mineral called *bauxite* and alumina refineries produce a semi-processed mineral called *alumina*. Primary smelters produce a metal called *primary aluminum* or *primary*, which includes a variety of alloys and shapes such as sheet ingot, casting ingot, and extrusion billet. Fabrication mills produce a wide range of products such as plates, tubes, and cables, which are shaped from primary aluminum. Figure 1 depicts the various aluminum production stages.

The first stage in the production process is the mining of bauxite, an ore composed of a mixture of minerals of at least 30% recoverable alumina. Bauxite is not a homogeneous ore, and differs in composition across deposits and sometimes within the same deposit. While alumina content is its most important variable, other variables and impurities also have important implications in the technology and cost of processing bauxite. Commercial prospects for a given bauxite deposit depend upon alumina and organic content, as well as impurities, availability of local infrastructure, distance from the refineries, and the bauxite market price.

Bauxite is refined into alumina by the Bayer process,[14] in which two to five tons of bauxite are required to produce one ton of alumina. All refineries use the Bayer process technology, however, each refinery must modify this process to suit the type of bauxite

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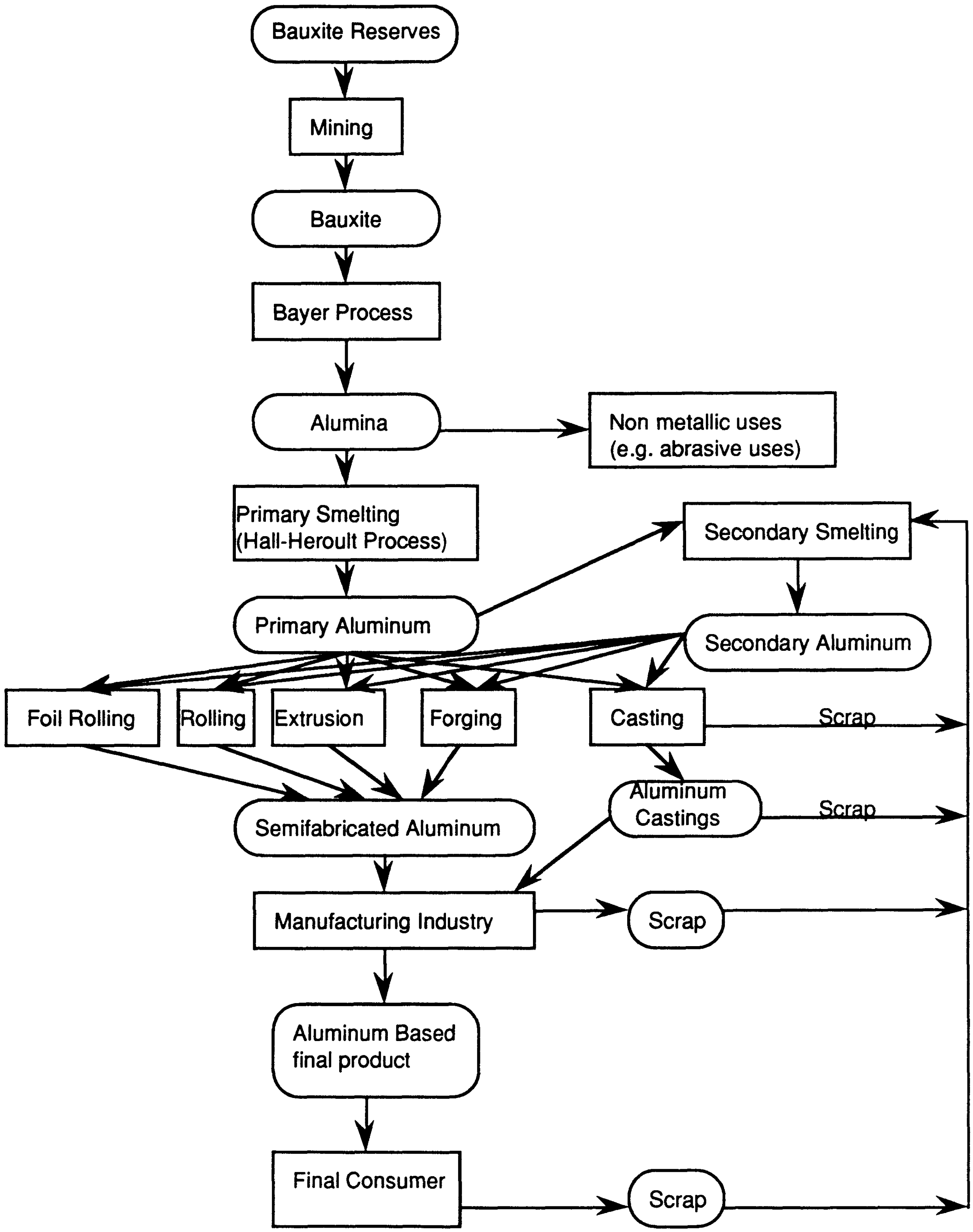
13 Upstream are the activities that involve bauxite mining and alumina refining. Downstream are activities related to semi-fabricated and fabricated products.

14 A.R. Barkin, Production of Aluminum and Alumina, Published on behalf of the Society of Chemical Industry, J. Wiley, 1987.

Figure 1. Stages and Flows in Aluminum Production.



Source: Merton Peck, The World Aluminum Industry in a Changing Era, Washington D.C., Resources for the Future, John Hopkins University Press, 1988) used. Substantial economies of scale exist in alumina refineries, with a minimum efficient scale approximately 700,000 tons per year, including the necessary infrastructure.

Primary aluminum metal is produced from alumina at a ratio of approximately two tons of alumina per one ton of primary aluminum, by the Hall-Herault process.[15] Though several variations to this process exist, their economics are similar. Primary smelters consist of individual pots arranged in one or more pot-lines. Economies of scale are significant, but not as large as in the case of alumina refineries.[16] For a single smelter, the efficient scale is between 100,000 to 130,000 tons per year.

Primary aluminum is used to make fabricated aluminum products through a variety of processes common to metalworking, such as rolling, casting, and extruding. Fabrications are used to manufacture items ranging from window frames, household foil, and engine blocks to aircraft wings. In terms of application, aluminum is second only to steel. Manufacturing operations are small in scale compared to those performed at smelters and refineries. Although economies of scale are usually not significant, for operations such as sheet, plate, and foil mills, there is a minimum efficient scale of 50,000 tons per year. Like most metal industries, the aluminum industry generates scrap from its operations and final products re-usage. The scrap is used in secondary smelting, which can be substituted for primary aluminum in most uses.[17] Finally, the processes used in the various stages of production have undergone few fundamental changes since the beginnings of the industry. Major improvements have focussed on increasing technology productivity and improving quality of outputs.

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[15] Ibid.

[16] Compared in terms of relative primary units.

[17] Merton Peck, The World Aluminum Industry in a Changing Era, (Washington D.C., Resources for the Future, John Hopkins University Press, 1988).

1.2. The Venezuelan Situation.

The Venezuelan aluminum industry typifies industrial development in Venezuela and is the result of an intentional government industrial policy, the development of energy-intensive industries, linked to the hydroelectric infrastructure in the Guayana region in development since the 1960's. In this section we will explain briefly the current economic situation of Venezuela and its aluminum industry.

1.2.1. Overview of the Economic Situation.

For the past 20 years, Venezuela has failed to invest its revenues from natural resources, especially from oil, into productive assets growth. This situation has come about because of, in the absence of a coherent and feasible development strategy,[18] the implementation of a set of different, often contradictory, policies, and increased direct economic controls and subsidies by the government. As a consequence, the system was incapable of generating sufficient growth from its productive capacity. Venezuela today remains highly dependent on oil which, until the 1986 collapse in oil prices, provided about 95% of its export earnings.[19] The country remains exposed to the volatility in oil prices, and more important, other productive industries remain underdeveloped.[20] Implemented policies have failed to address the problem of poverty effectively in government's development policies. In spite of continuous efforts, Venezuela's public sector is still inefficient and does not provide the basis needed for modernizing government operations to support a sustainable development strategy.

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[18] Based on the World Bank Report prepared for Venezuela, November, 1988.

[19] Banco Central de Venezuela, La Economía Venezolana en los Ultimos Treinta y Cinco años, (1987). See also, Harvard Business School, Venezuela 1988, (N9-389-034, 1989).

[20] Underdeveloped is defined as a strong dependency on Government policies and/or the incapacity to compete in the international market.

Relatively high growth rates of real GNP were achieved from 1960 to 1973 by taking advantage of the financial resources and foreign exchange provided by oil.[21] During the 1970's, starting with the 1973 oil boom, the government's role expanded, characterized by a rapid increase in direct production, promotional activities, and regulatory interventions. Industrial development was heavily promoted, based on energy-intensive industries such as steel, aluminum and petrochemicals; an effort which fostered large infrastructure investments, including large hydroelectric developments.

Simultaneously, due to depressed relative prices for traded goods, the industrial sector became dependent on government promotional policies. Government policies encouraged changes in factor use toward less intensive use of labor, more intensive use of land and capital, and more generalized use of imported inputs.[22] However, the magnitude of the public sector investment program in 1974-78 proved too ambitious, and inefficiencies in the use of resources were substantial. As a result, during 1978-79, the government was forced to undertake contractional policies characterized by investment cut backs.

During the 1980's, despite a second oil boom in 1980, production also declined as inappropriate policies encouraged capital flight rather than growth; however, inflation was moderate from 1982 to 1986.[23] Between 1986 and 1988, although policy again shifted to stimulation and GNP growth was about 6%, this growth was characterized by a sharp deterioration in the balance of payments and by increasing inflation. In 1986 average Venezuelan oil prices fell by almost 50%, from $25.7 per barrel in 1985 to just $13.6 per barrel in 1986.[24] The government responded to this situation by drawing down external reserves and pursuing short-term financing policies.

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21 Banco Central de Venezuela, La Economía Venezolana en los Ultimos Treinta y Cinco años, 1987.

22 Based on interviews in various industrial sectors.

23 Ibid.

24 Based on interviews in the oil sector.

By the end of 1988, Venezuela's economic situation had become critical: operating reserves were depleted, and imports were increasing, as it was clear that the government would implement a major devaluation. Inflation continued to accelerate, and by January 1989, there were substantial shortages of primary goods in the markets. High levels of uncertainty in all sectors set up a critical situation.

In light of this situation, in 1989 the new government initiated a program to redefine the role of the public sector. The objective was to reduce the participation in direct investment, and to restructure the complex regulatory and institutional framework which distorted the economy. Equally important, the program was expected to encourage private sector activity and investment in the aluminum and petrochemical sectors, and various medium and small industries.

1.2.2. Summary of the Venezuelan Aluminum Industry.[25]

The Venezuelan aluminum industry is owned by the government and managed by Corporación Venezolana de Guayana [CVG]. Its underlying objective is to help diversify the Venezuelan economy from the oil sector. CVG-Aluminum [CVG-AL] is now under expansion due to expected increases in world aluminum demand.[26] The sources of value for the Venezuelan aluminum industry stem from low cost of energy and labor, and close proximity to the sources of raw materials.[27] CVG-AL's target is to produce two million tons per year of primary aluminum within a balanced, vertical integrated structure.

Figure 2 shows the location of the aluminum industry in Venezuela. Located around Puerto Ordaz, about 600 km from the capital of Caracas, it is composed of an alumina refinery run by Interalumina C.A., two smelters run by Alcasa C.A. and Venalum C.A.,

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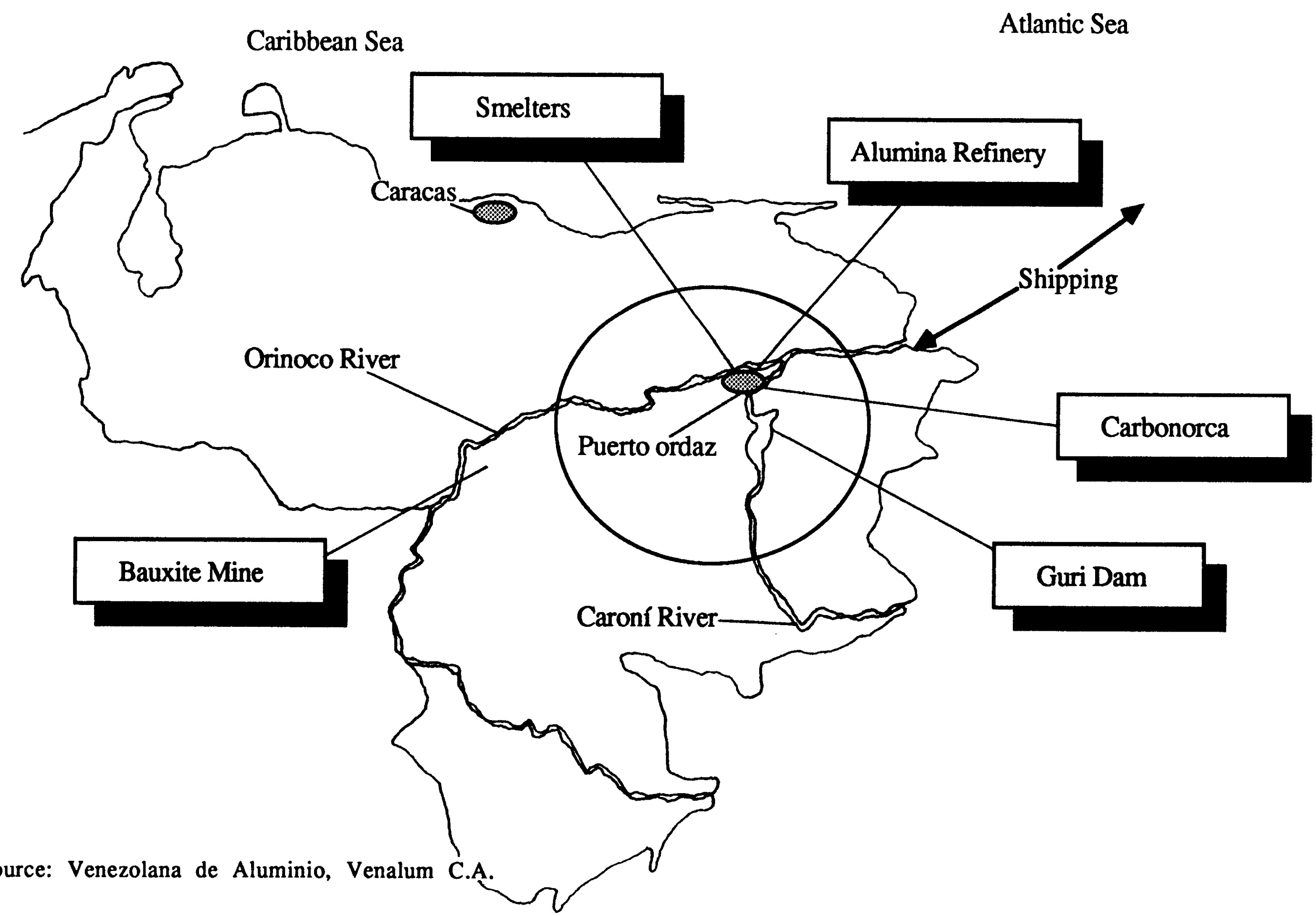
25 This section is based on information from CVG-Planificación Corporativa and CVG-Subsidiaries' Corporate Plans.

26 Shearson-Lehman-Hutton, Annual Review of the World Aluminum Industry, 1989, (pp. 41-48).

27 Venalum C.A., Plan Corporativo 1989-1993, p.75.

Figure 2. Location of the Aluminum Sector in Venezuela.



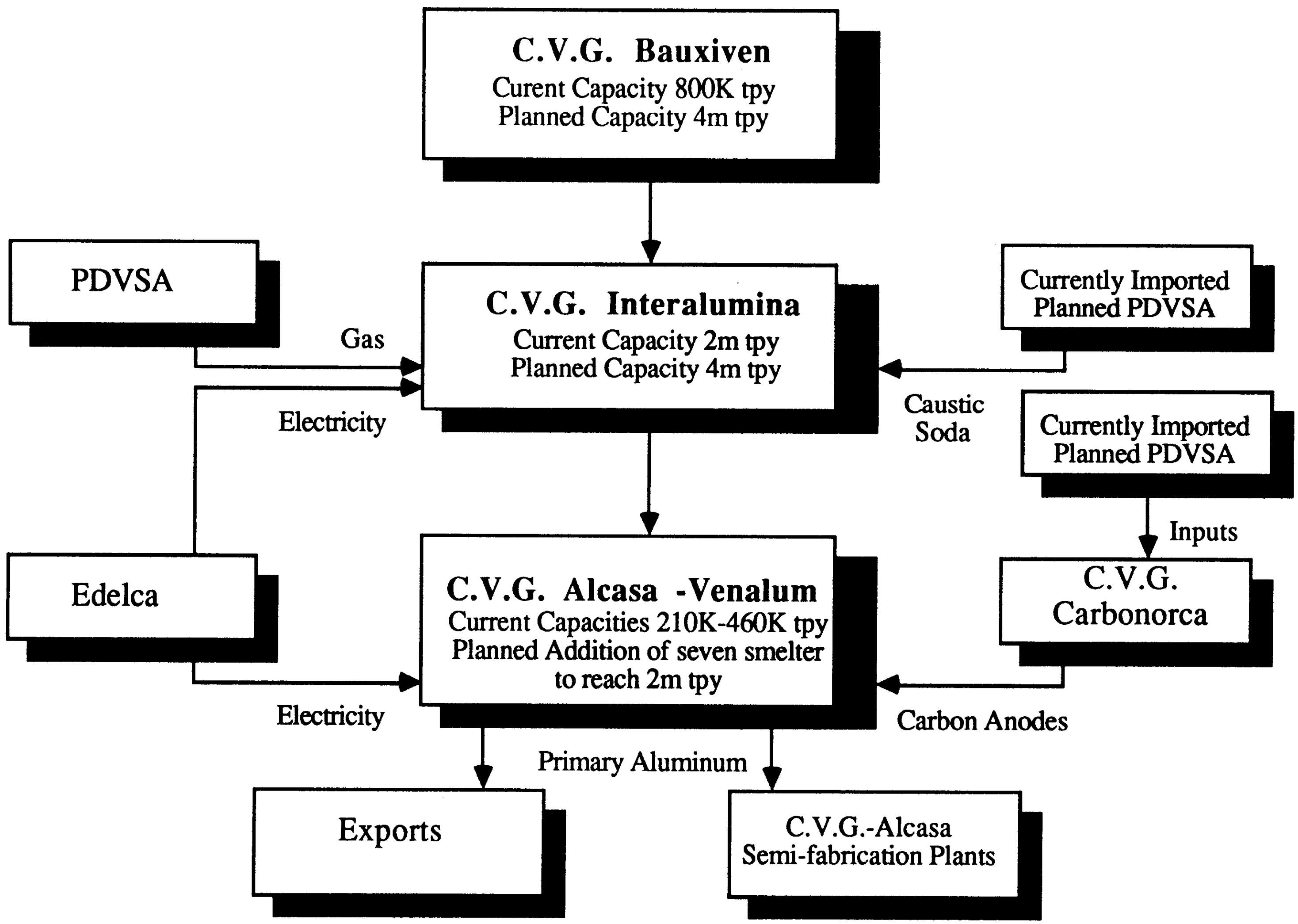
Source: Venezolana de Aluminio, Venalum C.A.

and the Los Pijiguaos bauxite mine run by Bauxiven C.A. The primary smelters and refinery are located together along the Orinoco River close to Puerto Ordaz, having available a well-developed infrastructure system. These plants also have the benefit of being close to the Guri dam, which provides hydroelectric power to the smelters; and to low-cost natural gas in the case of the alumina refinery. However, the mine is located about 600 km from Puerto Ordaz in an undeveloped area requiring high infrastructure investment and an effective solution to bauxite transportation from the mine to the refinery. The location of the industry along the Orinoco River provides an easy and cheap transportation route.

1.2.2.1. CVG-Aluminum [CVG-AL] Company Profile.

CVG-AL, the organization within CVG in charge of managing the aluminum sector, is involved in all stages of the aluminum production process. The corporation's goal is to develop a balanced, vertically integrated industry from bauxite to primary aluminum. The structure of the CVG-AL presented in Figure 3 shows the current and planned capacities at each stage of production. Industry inputs for the industry are sourced by PDVSA [Petróleos de Venezuela S.A.], which provides CVG with the natural gas required by Interalumina C.A. as its main source of energy, and some of the inputs for the carbon anodes production required for primary aluminum smelting. PDVSA is expected to cover all caustic soda requirements for alumina refining now imported in its totality. The energy required by the smelters is generated at the Guri dam, while needed carbon anodes are mainly imported, along with some quantity provided by CVG-Carbonorca C.A. In the future, it is expected that Carbonorca C.A. will totally cover all primary aluminum industry requirements. Table 1 is self-explanatory, and shows the current capacity of the industry and its future plans.

Figure 3. Structure of the Venezuelan Aluminum Industry.



Source: Venezolana de Aluminio, Venalum C.A.

Table 1. General Summary of the Venezuelan Aluminum Sector.

Resources	Present Capacity	Source	Future Capacity	Remarks
Bauxite Expansion	460K tpy	Los Pijiguaos.	8.0m tpy	Bauxiven C.A.
	2.4m tpy	Imported.	--0--	
Alumina	1.3m tpy	Interalumina Refinery.	4.0m tpy	Interalumina expansion and new refinery.
Aluminum	670K tpy	Alcasa-Venalum Smelters.	2.0m tpy	Further Alcasa expansion and seven new smelters.
Carbon Anodes	140K tpy	Existing captive plants Carbonorca Central anode plant.	1.2m tpy	Carbonorca I and and expansion to 750K tpy.
Electrical Energy	10K megWatts	Edelca - Electrification Caroní Hydro-Power.	26K megWatts	New Hydro-Electric Plants.
Natural Gas	n/a	Petroleos de Venezuela (PDVSA)-Corpoven.	n/a	Capacity available for all operations.
Petroleum Coke	280K tpy	U.S.A imports	900k tpy	PDVSA Project plus imports.
Coal Tar Pitch	60K tpy	U.S.A / Europe	180K tpy	Imports. Also, research for blending petroleum pitch with coal tar pitch.
Caustic Soda	100K tpy	U.S.A	300K tpy	Imports / Project in phase to produce caustic soda (PDVSA).
Aluminum Technical manpower.	12K	CVG-Aluminum	30K	Increase aluminum technical manpower base.

Source: Venezolana de Aluminio, Venalum C.A. September-1989.

CVG-AL revenues are almost entirely due to sales of primary aluminum. Sales of alumina and downstream products amount to less than 20% of the total.[28] Therefore, revenues are not especially sensitive to movements in the price of alumina or downstream products. Because of significant bauxite requirements, CVG-AL's position is sensitive to changes in bauxite prices as long as its alumina operations depend on imported bauxite. However, the negative impact of bauxite prices on revenues is expected to decline as domestic bauxite production increases.

Huge cost advantages stemming from cheap hydroelectric power put CVG-AL in a particularly strong position in the primary aluminium industry.[29] As shown by this study, CVG-AL's emphasis should be on primary production in spite of its exposure to primary price fluctuations. Alumina production is also competitive, but less so than primary. Bauxite costs are high, and will probably remain so until Bauxiven C.A. reaches full, efficient production.

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[28] CVG-Planificación Corporativa data base.

[29] CVG has the potential of becoming the lowest primary producer in the industry as a result of the low-energy tariff for the industry.

Chapter 2

The Alumina Industry - Baseline Analysis

This chapter analyzes the alumina industry from the perspective of the alumina free-market. The objective is to study the alumina transactions made outside integrated systems to avoid possible distortions in the use of internal transfer pricing policies. We will first look at strategic groups involved in the alumina industry, the classification of which resulted from grouping companies according to degree of vertical integration, alumina position,[30] and, to a lesser extent, historical development. This chapter also analyzes alumina industry concentration, barriers to entry, cost structure, and a sensitivity analysis on the main cost determinants: investment costs, bauxite, caustic soda, energy and labor. Finally, it presents a baseline recommendation on expanding alumina capacity.

2.1. Strategic Groups.

This section analyzes the different strategic groups and defines their main characteristics and interests. The relationships among the strategic groups depicted in Figure 4 show the different groups and their relationship through their alumina and bauxite transactions. This figure is defined by two dimensions: the degree of vertical integration and the alumina position. From the figure, two points are important to note: Miners and Refiners are located within the same group, given their similarities in characteristics and interests. As explained later in Chapter 3, the strong dependence between Miners and Refiners makes it necessary to consolidate them into one strategic group. The arrows represents the flow of alumina and/or bauxite from one group to another.[31]

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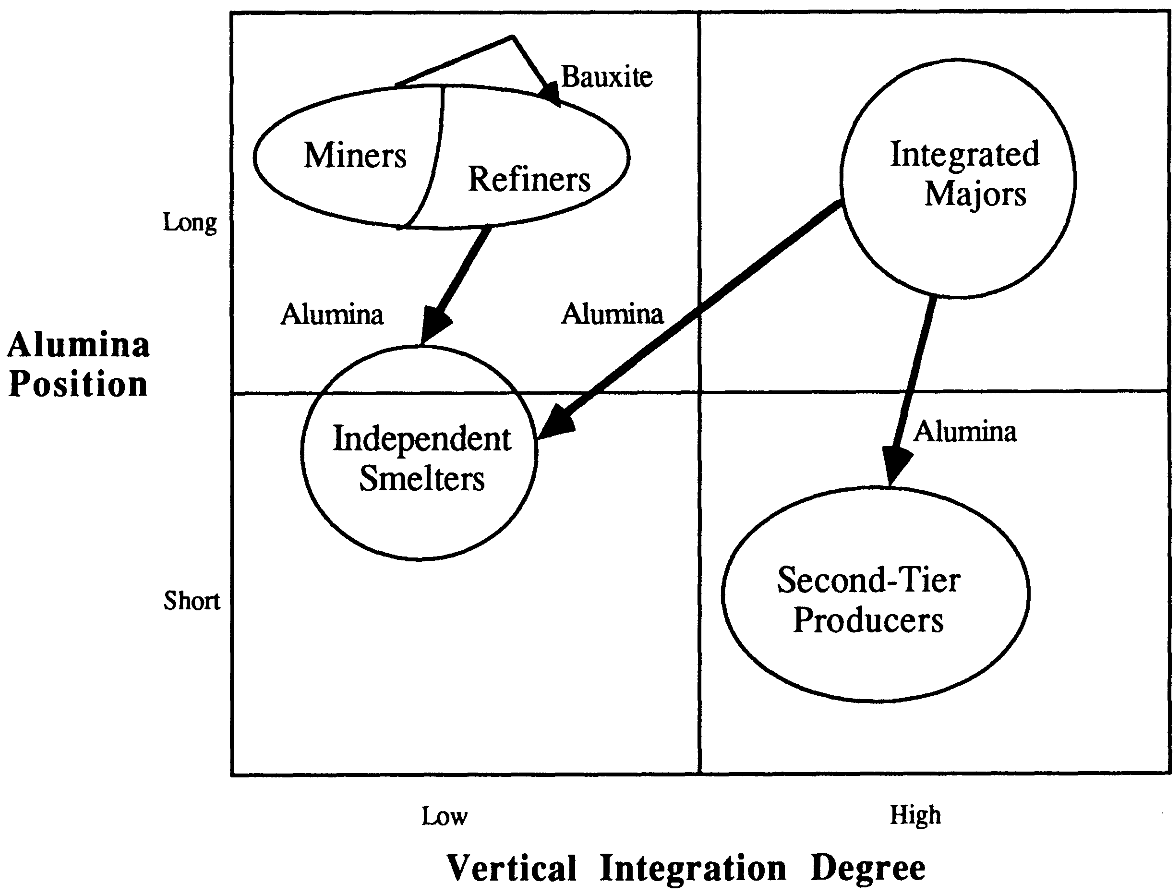
[30] Alumina position is defined as long or short. Long position refers to the availability of alumina to the free-market after all the internal requirements have been fulfilled. Short position refers to the dependency on the free-market to fulfill alumina requirements.

[31] A sixth group, defined as Independent Fabricators, would complete the list of groups within the aluminum industry; however, since there is no relationship of this group with alumina, it was excluded from the analysis.

Figure 4. Strategic Groups Relationships.



Source: Based on Classification made by Colin Pratt, "Is Vertical Integration in Aluminum Really Necessary". Prepared for: Metal's Week Second Aluminum Symposium, (1989).

To specify the location of each group within the aluminum industry production process, Figure 5 shows a simplified version of the process depicted in the aluminum production figure [Figure 1]. The location of each group depends on its free-market position at each stage of production. Differentiation is made between the integrated system, where products flow through internal transfers with no interaction with other producers and/or buyers, and the free-market segment, which represents the arm-length transactions side. The existence of the Miners and Refiners in the bauxite and alumina stages is notable. As explained before, mines and refineries are dependent on one another due to bauxite mineralogy. Also, at the end of the production process it is shown that Independent Fabricators' group represents the demand side for arms-length primary aluminum transactions. The analysis of this group is beyond the scope of this study.

After locating each of the strategic groups in the process and seeing their relation to one other, each is now defined: The "Integrated Majors" and "Second-Tier Producers" groups are very similar in characteristics and interests. Both groups are characterized by their strong integration of primary aluminum and down-stream operations.[32] Both are focused on down-stream markets as their main source of revenues. Table 2 shows the firms included in each group.[33]

Apart from size and history, the alumina balance is what distinguishes the Integrated Majors from Second-Tier Producers. Contrary to the Second-Tiers alumina position, the Integrated Majors group includes the six companies substantially long in alumina. In 1989 this group controlled more than 60% of the free-market alumina supply to firms short in alumina.[34] Although some of the members are closely balanced in primary

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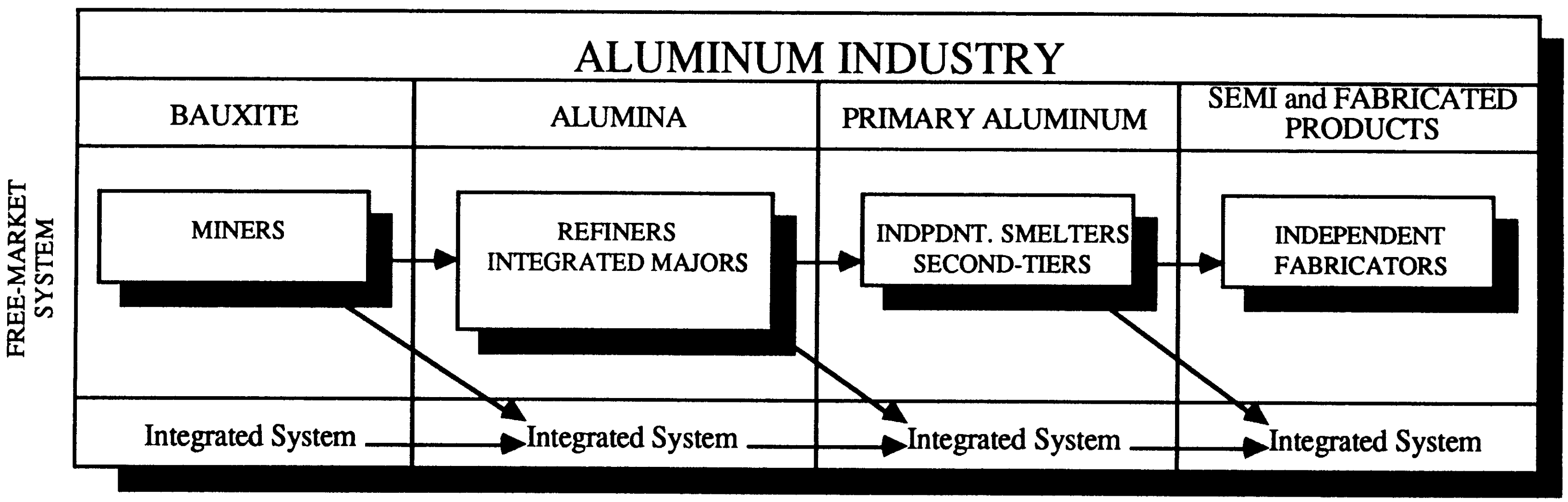
32 Colin Pratt, "Is Vertical Integration in Aluminum Really Necessary?," Prepared for: Metals Week's Second Aluminum Symposium, (1989), pp. 9-11.

33 For locating each company in its country of origin, see International Primary Aluminum Institute [IPAI], Statistical summary, Volume 4 (part), (1987-1988): 30-34.

34 Shearson-Lehman-Hutton, Annual Review of the World Aluminum Industry, (1989), pp.41-48.

Figure 5. Location of Strategic Groups in the Production Proccess.



and may, in certain circumstances, be in a short position, they are characterized by being long in aluminum production. This group however, is no longer the main supplier of the aluminum free-market, currently dominated by the Independent Smelters group.

Table 2. Integrated Majors and Second-Tier Producers.

Integrated Majors	**Second-Tier Producers**
Alumina Long:	*Alumina Balance:*
Alcoa	Alumix
Alcan	Inespal
Kaiser	
Pechiney	*Alumina Short:*
Alusuisse	VAW
	Noranda Aluminum
	Alumax
	Austria Metal
	Hoogovens
	Granges

Source: Venezolana de Aluminio, Venalum C.A.

The main concern for both the Integrated Majors and Second-Tier Producers is the maintenance of a stable pricing system of downstream products. Important for this group is the decline in concentration of downstream markets due to the entry of new Independent Fabricators. Even though sales of primary aluminum are not an important source of revenue for the Integrated Majors and Second-Tiers, these groups are not indifferent to volatility in the primary price. Primary prices exercise pressure on semi-fabricated prices, and low prices in the primary market create entry opportunities for new Independent Fabricators, reducing the Majors' and Second-Tiers' respective market shares.

The "Miners/Refiners" group traditionally has been a small and weak strategic group. Closely linked because of bauxite physical heterogeneity and its market imperfections, there is a strong dependence between bauxite miners and alumina refiners. The growth of this group has not been matched by the growth of the Independent Smelters group. This is because refining plants are associated with high initial capital outlays, large minimum efficient scale, and high volatility in the output's price. These facts imply that an alumina refinery is an expensive and risky project. Further, a large part of the alumina required by Independent Producers is supplied by the Majors group, which collectively run a large alumina surplus. Table 3 shows the firms included in the "Miner/Refiners" group.

Table 3. Miner/Refiners.

Refiners:	**Miners:**
Billiton	IBA Member States
Alcoa of Australia	e.g. Guyana
Comalco	Indonesia
Jamaican Government	Greek Bauxite Producers
	MRN

Source: Venezolana de Aluminio, Venalum C.A.

The main concerns of this group are the possibility to capitalize on low-cost bauxite and energy, and the existence of a balanced, alumina free-market so that prices are not driven down by overcapacity. Finally, Miners/Refiners are also interested in stable alumina contracts to avoid output price volatility.

The "Independent Smelters" group, except for CVG[35] and to some extent Comalco, are predominantly primary aluminum producers and are not developed, if at all, downstream. The reason Independent Producers entered the aluminum industry was the access to a low-cost energy source, and for most of them this remains as main source of competitive advantage. Independent Producers are the most recent entrants in the industry, and except for CVG, the firms in this group are short of alumina, and depend on supplies from one of the Integrated Majors and/or the Miners/Refiners for their alumina needs. Table 4 shows the companies included in this group.

[35] CVG is located in this group only temporarily due to its changing balance. Currently its position is not clearly defined. The stated policy is vertical integration, although CVG's position is clearly unbalanced with a long alumina and a short bauxite position. CVG is included in this group because its origin was as an independent smelter given its low energy cost position. However, CVG's current interests lie between that of Independent Producers and of Miners/Refiners.

Table 4. Independent Smelters.

Short of Alumina:	Balanced/Long in Alumina:
Aluvic	CVG
CVRD	Comalco
SGF	
Hydro-Aluminum	
Elkem	
Aluminum Bahrain	
Dubai Aluminum	
Aluar	
Alusaf	
Egyptalum	

Source: Venezolana de Aluminio, Venalum C.A.

Independent Smelters maximize their profits when primary aluminum prices are relatively high and, coinciding with the Majors Group, when alumina prices are low. Since their key advantage is low energy cost, Independent Smelters should focus their future plans on capacity expansion within the smelting stage. If expansion exceeds the overall market growth, they may need to capture market share from the Majors group. Otherwise, overcapacity might drive primary aluminum prices down.

2.2. Market Concentration.

In theory, forward integration by monopolists or oligopolists can enable them to practice price discrimination between different markets.[36] Price discrimination in the alumina industry occurs when different transfer pricing policies are used, dependent on the buyer and the contractual agreements of the parties concerned. Although the alumina industry can change to a more competitive industry as concentration declines, the concentration of vertically integrated producers is expected to remain high, especially Alcoa.[37] Up to the mid-1970's, the alumina market could be said to be characterized by

[36] F.M. Scherer, Industrial Market Structure and Economic Performance, (Second Edition), Rand McNally College, 1980, (pp.315-319).

[37] Until the 1960's the alumina market simply did not exist and primary producers were forced to backward integrate.

sticky, administered pricing, such that the market failed to clear through price.[38] Since then, a declining market concentration has led to a more competitive environment[39] where prices are more responsive to changes in alumina supply and/or demand. See Table 5 and Figure 6 which show the concentration levels for the alumina market in 1988.

As shown in Table 6, the trend for shares of the six Majors in the alumina market has been in a continuous decline. The arm-length market is expected to increase in size, although Alcoa's concentration is expected to remain.[40] The implication is that while alumina market size and liquidity will increase, market concentration will decrease. Because of this, new entrants will have an incentive to join the Independent Smelters group, taking advantage of competitive alumina prices.

2.3. Cost Structure.

Although infrastructure costs are not considered explicitly, they would represent important costs for greenfield projects in developing countries. Fixed capital costs which vary from refinery to refinery depending on location, infrastructure needs, and future plans, constitute about $700-1,200 per ton of installed capacity.[41] As for any industrial plant, unit capital costs for alumina refineries diminish with increasing plant size. Minimum efficient scale is reached at about 700,000 tons per year.

Table 7 presents the operating costs distribution of alumina refining, based on raw materials, energy labor, and other costs (this cost structure analysis is expanded in Chapter 3). As shown in the table, cost advantage in alumina production stems from the proximity

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38 John A. Stuckey, Vertical Integration and Joint Ventures in the Aluminum Industry, (Cambridge MA., Harvard University Press), 1983. pp. 88-91.

39 Colin Pratt, Is vertical Integration in Aluminum Really Necessary?, Prepared for: Metals week's Second Aluminum Symposium, 1989, pp.9-11.

40 Ibid.

41 Frank A. McCawley, and Luke H. Baumgardner, Aluminum, (Preprinted) from Bulletin 675, Mineral Facts and Problems, 1985 Edition, Bureau of Mines, pp. 15-16, and Venalum C.A. data base.

Table 5. Concentration in the Alumina Market , 1989.

Company	'000 tpy.	%	Cumulative %
Alcoa	8,560	26.8	26.8
Alcan	4,080	12.8	39.6
Reynolds	2,570	8.1	47.7
Pechiney	2,310	7.2	54.9
Kaiser	2,000	6.3	61.2
Billiton	1,646	5.2	66.4
CVG	1,344	4.2	70.6
Comalco	1,180	3.7	52.9
Alusuisse	1,140	3.6	77.9
Inespal	1,140	3.6	81.5

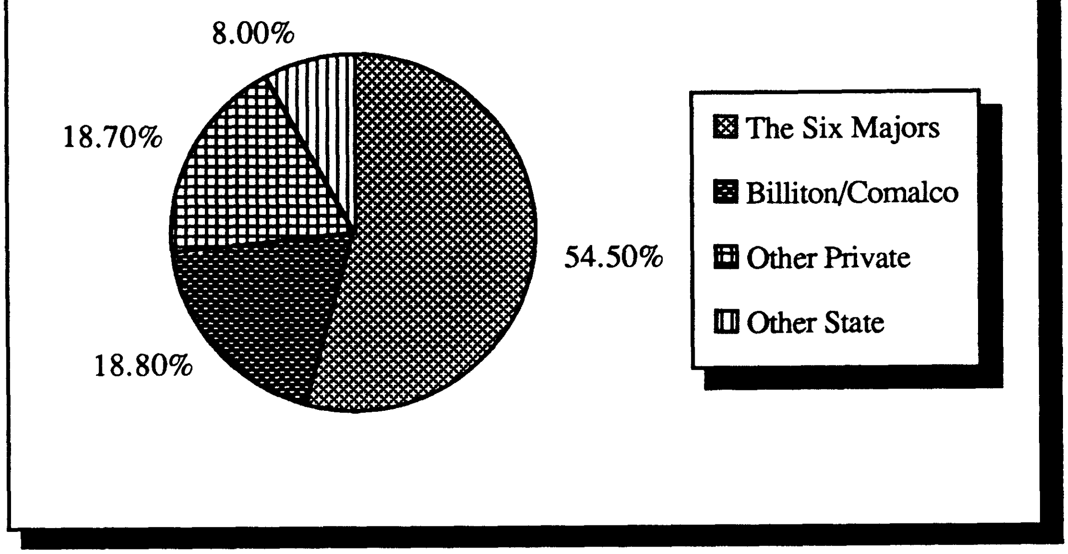
Source: Venezolana de Aluminio, Venalum C.A.

Table 6. Shares of the Six Majors: 1955, 1963, 1971, 1979, and 1988.

Company	1955	1963	1971	1979	1988
Alcoa	24.8	18.0	23.0	27.6	26.8
Alcan	27.3	26.3	19.0	13.9	12.8
Reynolds	16.9	15.4	11.1	9.2	8.1
Kaiser	12.3	11.7	12.2	9.4	6.3
Pechiney	5.1	8.6	11.0	8.9	7.2
Alusuisse	4.2	4.6	2.9	4.8	3.6
Total	90.6	84.6	79.2	73.8	64.8

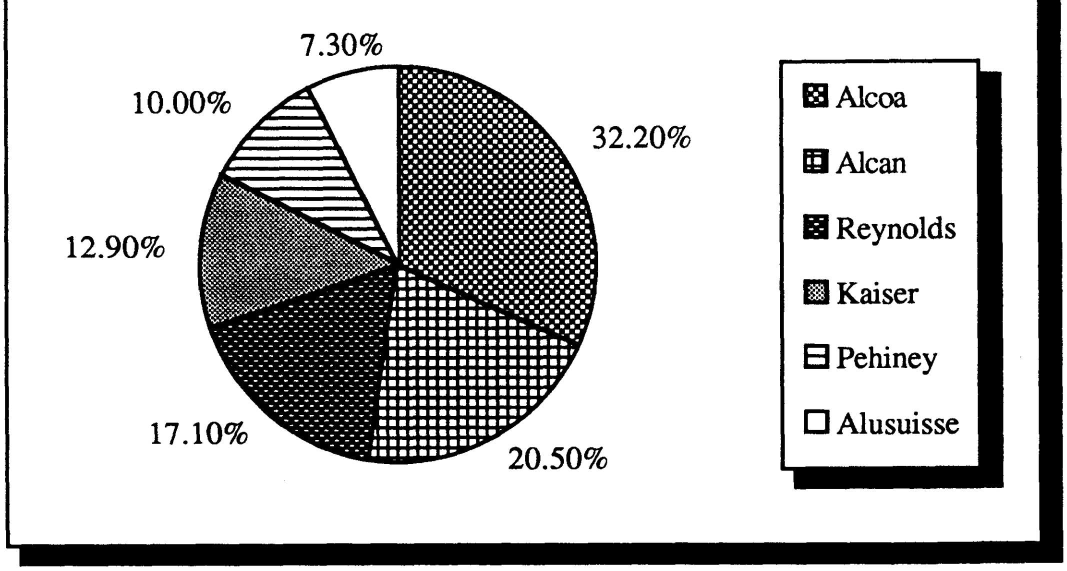
Source: John A. Stuckey, Vertical Integration and Joint Ventures in the Aluminum Industry, Harvard University Press, 1983, p. 84.

Figure 6a. Distribution of Alumina refining Capacity in 1988.



Source: Shearson-Lehman-Hutton. Annual Review of the World Aluminium, 1989, p. 45.

Figure 6b. Alumina Refining Capacity Controlled by the Six Majors, 1988.



Source: Shearson-Lehman-Hutton. Annual Review of the World Aluminium, 1989, p. 45.

to a low-cost source of bauxite and the low-cost source of energy and caustic soda. For a non-integrated firm, alumina supply has been of high variability, resulting in an unpredictable market. However, we could expect a more segmented market in the medium term, where competitive pricing might prevail.

Table 7. Alumina Operating Costs Variations, 1989.

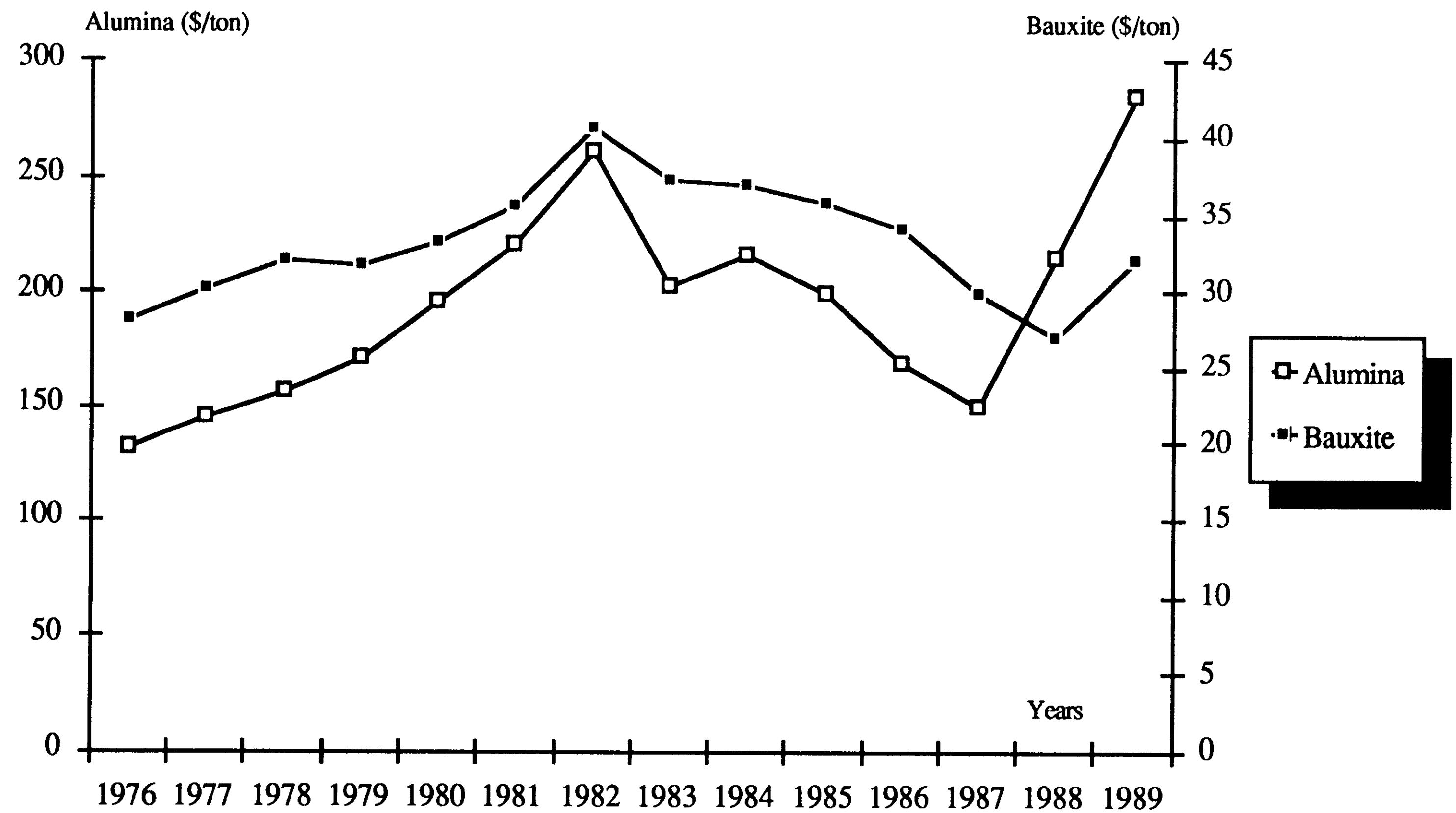
	Total	Bauxite	Caustic	Labor	Energy	Other
Mean ($/tn)	127	43.9	22.0	18.0	33.6	9.5
As % of Total	100	34.5	17.3	14.2	26.4	7.6
Std. Deviation	27.2	22.0	6.9	9.9	14.1	2.4

Source: Venezolana de Aluminio, Venalum C.A.

2.4. Alumina Prices.

Spot and contract alumina prices have been characterized by high volatility and, in contrast to primary aluminum prices, alumina prices do not follow any reference cycle. Figure 7 shows the alumina and bauxite prices imported into the United States. Bauxite and alumina prices generally move together, although when the alumina market is in tight balance, as in 1982 and during the last two years, alumina prices are more volatile than bauxite prices. Given the dependence between mines and refineries, usually governed by a vertical structure organization, bauxite transactions are usually made, on a cost-plus basis. This type of contractual agreement will recognize a band for the bauxite operations' profit margin, which will increase as alumina prices increase, as in 1982. However, if the price of alumina is too high, there is a limit to bauxite prices imposed by escalation formulas used to set a floor and a ceiling price for the product. In the last two years, bauxite prices increased, but not as much as alumina prices. What, then, causes alumina prices to fluctuate so much?

Figure 7. Prices of Alumina and Bauxite imported into US (Current $).



Source: Venezolana de Aluminio, Venalum C.A.

Figure 8 shows the alumina and aluminum prices imported into the U.S. As we can see, there are clear time lags between the two markets, created mainly by time delays in renegotiating alumina contracts resulting from a market characterized by contractual transactions with few spot sales. The primary aluminum price, however, is not the only factor affecting alumina prices. Prices also depend on the negotiation power of the parties concerned, the balance position of supply and demand for the free-market, and the distance between the refiner and the buyer, explained in detail in Chapter 5.

2.5. Barriers to Entry.

Clearly, low operating costs are a major source of competitive advantage, and access to them represents a major barrier for new entrants in alumina production, resulting in a cost-focused industry. The sources of cost advantage are primarily natural resource-based, such as low-cost bauxite deposits, usually in the hands of host governments. They play a major role in the alumina refining stage, especially in developing countries. Industrial policy, such as subsidized transfer pricing and long-term arrangements for low-energy tariffs, is the main instrument for promoting the industry. Governments might also encourage the development of their state-owned enterprise through tax benefits and low-interest, long-term financing.

As for any capital-intensive industry, alumina refineries require high initial capital investments, about $700-1,200 per ton, plus contingencies and required infrastructure investments as initial outlay.[42] The most important risks associated with this investment are imperfect input markets and cost variability, excessive output price volatility, political risk in the case of smelters located in unstable countries, or dependence on sources of supply from risky countries, volatility of exchange rates, and the cyclical nature of the business due to its correlation with the economy business cycle.

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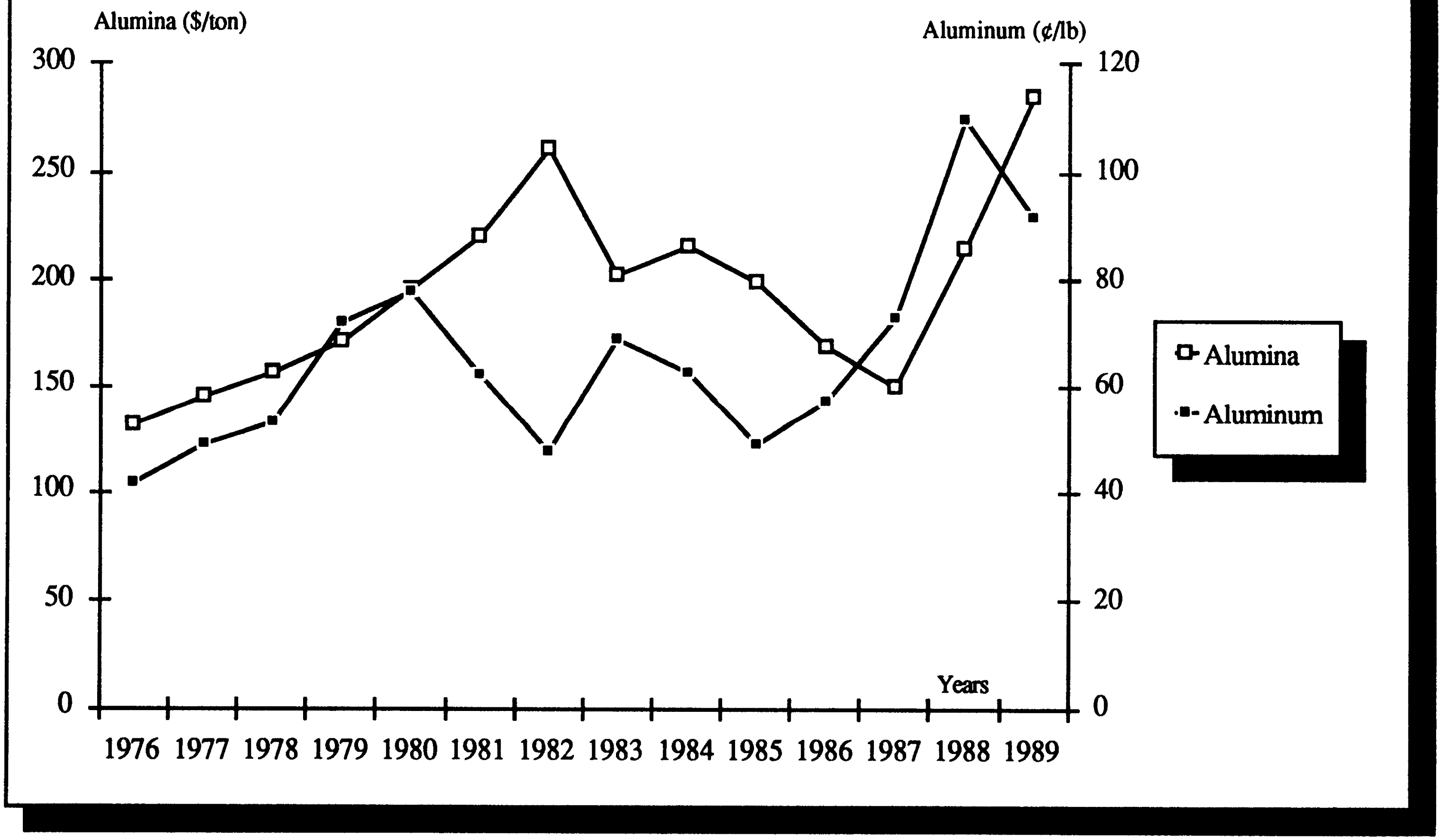
42 Ibid.

Figure 8. Alumina Contract Prices in US and Metals Week Aluminum Prices. (Current $).



Source: Venezolana de Aluminio, Venalum C.A.

Given the historical, dominant vertical integration structure in the industry, alumina distribution channels have been controlled by major integrated producers. However, due to increasing fragmentation of the industry as a whole, there are new distribution channels related to Independent Refiners, thus reducing market failure risk.[43] The technology is owned by firms in the Integrated Majors group. Even though technology is fairly homogeneous, it is costly for new entrants to gain access, and technical expertise as well. Especially for developing countries, greenfield projects have infrastructure needs which represent a high-cost entry barrier to the industry. On average, infrastructure requirements could increase initial capital outlays between $100-400 per ton.[44]

2.6. Sensitivity to Major Alumina Investment Determinants.

After describing the main determinants in the alumina industry, this section now presents baseline results, and their sensitivity to the most important variables: investment costs, bauxite costs, and alumina prices. Our aim is to draw a baseline conclusion as a framework for a further detailed analysis on the issues raised in this chapter. The results and sensitivity analysis are based on the simulation model described in Chapter 6, and the figures presented are drawn from the results using the base case simulation parameters presented in Table 8.

As shown in Figures 9-11, the base case scenario which assumes an above average state-of-the-world[45] results in a just positive NPV. Even though neither option equivalents nor terminal values cash flows are considered in the valuation model [see assumptions in Chapter 6], the results show the expected zero-NPV outcome coinciding with our initial expectations. This outcome might be explained by the fact that (1) alumina is an intermediate good, for which there is no developed market, (2) the parameters are based on

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43 Colin Pratt, "Is vertical Integration in Aluminum Really Necessary?," Prepared for: Metals Week's Second Aluminum Symposium, 1989.

44 Venalum C.A. data base.

45 States-of-the-World can be pessimistic, average, or optimistic.

data as if the project were to be built in Venezuela by CVG-AL which, as shown later, does not have clear competitive advantages in alumina production, and (3) the market dominance of contractual agreements, in principle, are zero-NPV agreements if risks are assumed to be well diversified.

Table 8. Base Case Simulation Parameters.

Alumina Price	275 ($/ton)
Alumina Production Schedule	('000 ton,year) (100,3);(650,4);(900,5);(1000,5-22)
Inflation Rate	1.04 (1+%/year)
Investment Costs	800,000 ($'000)
Construction Period	3 (Years, 2<>6)
Percentage Construction Completion per Year	(1,20%);(2,40%);(3,40%) (%,year)
Depreciation Period	20 (Years)
Bauxite Costs	25 ($/ton Bauxite)
Caustic Soda Costs	200 ($/ton Caustic Soda)
Energy Costs	15 ($/ton Alumina)
Labor Costs	15 ($/ton Alumina)
Equity Participation	30 (%)
Debt Participation	70 (%)
Interest Rate on Debt	10 (%)
Debt Repayment Period	15 (Years)
Pre-opening and Organization Costs	8,200 ($'000)
Amortization Period for Preop.&Org.Costs	5 (Years)
Unleveraged Beta for the Project	0.92
Risk Free Rate	0.08
Market Risk Premium	0.086

In terms of risk, alumina investments are highly sensitive to alumina prices, bauxite costs, and investment costs, as depicted in Figures 9-11. Because of the high sensitivity to alumina prices and their volatility, refineries will be forced to hedge their positions such that, if risks are well diversified, will result in expected zero-NPV investments.[46] Also, alumina sensitivity to environmental conditions, such as humidity, makes alumina transportation difficult and does not permit the product to be stored for more than two months, increasing the risky nature of alumina investment.

46 Hedge refers to the elimination of any risk by protecting the investment from any downturn at the cost of giving up the upside potential.

Figure 9. Sensitivity to Alumina Prices ($/ton).

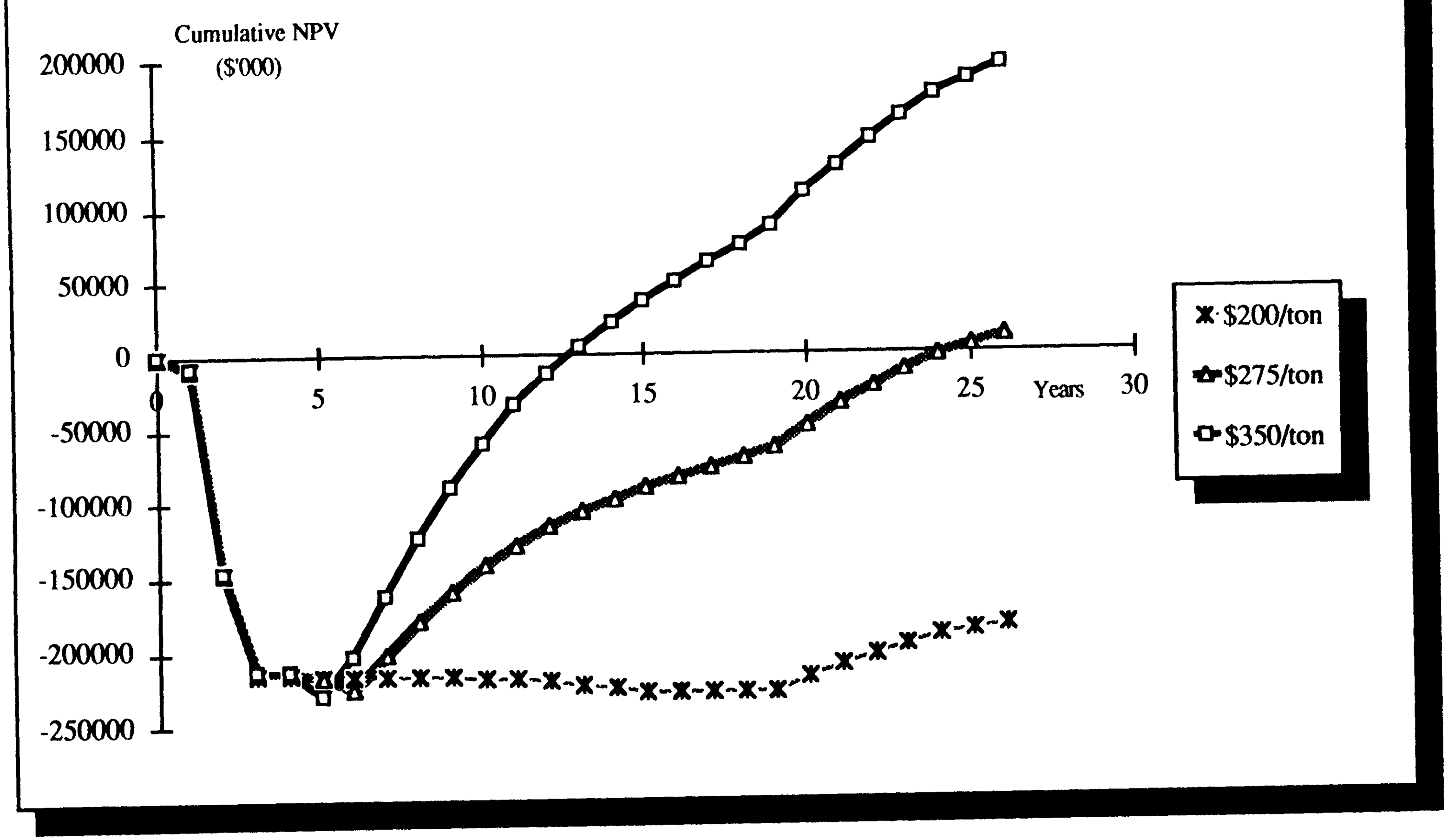


Figure 10. Sensitivity to Bauxite Costs, ($/ton).

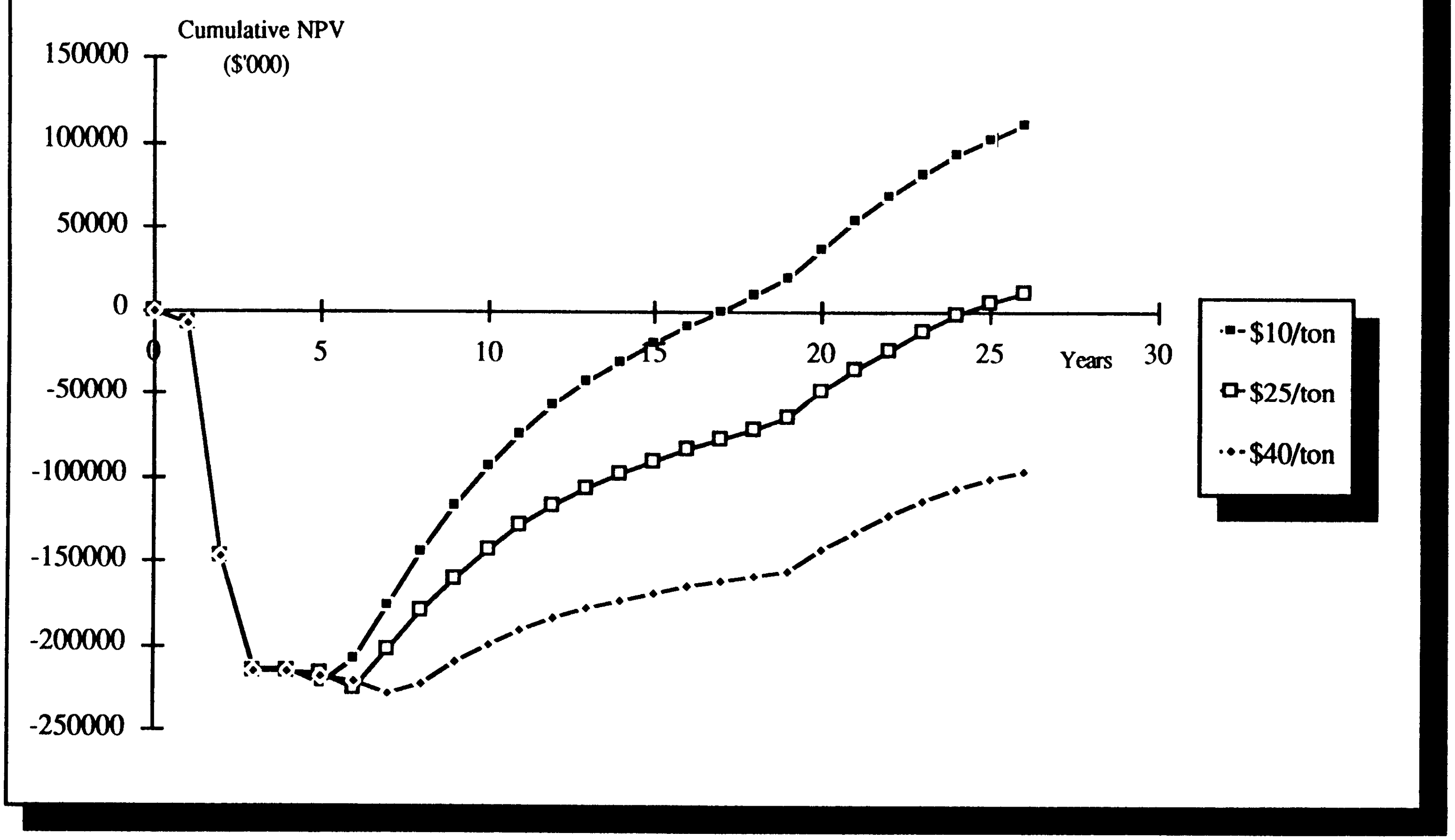
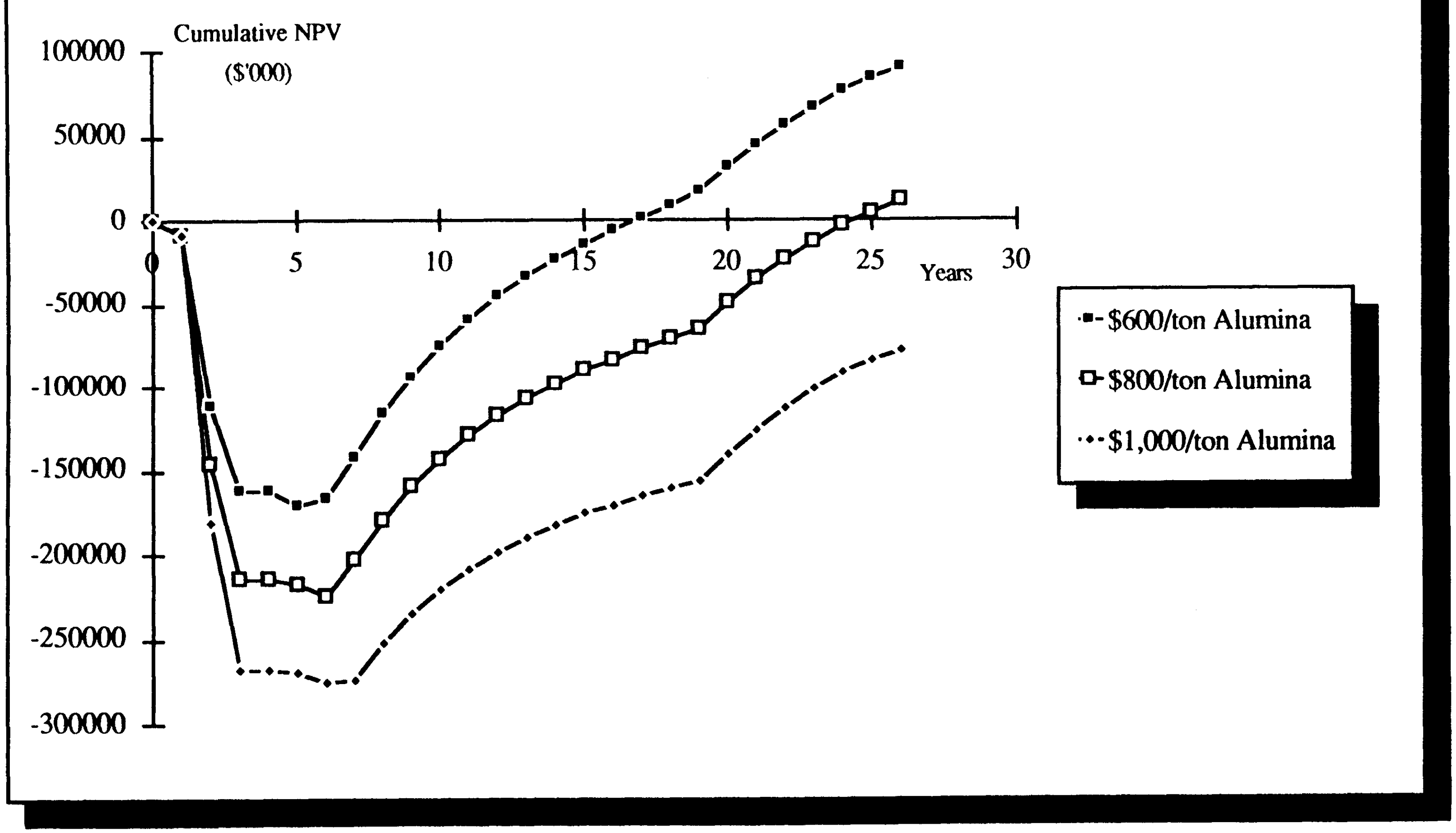


Figure 11. Sensitivity to Investment Costs, ($/ton Alumina).



Finally, given the high initial capital outlays required, the uncertainties of the market, the risky nature of the project, and CVG-AL's currently long in alumina, we do not recommend at this point expanding alumina capacity in Venezuela. To support this assessment, strategic issues across the alumina industry, its cost structure, and the valuation model cited in this section are detailed in the following chapters. Our objective is to present a complete analysis that not only considers the project appraisal, but also analyzes the factors that affect the organization of the industry, and responsiveness of the input and output markets to changes in capacity.

Chapter 3
Strategic Issues for the Alumina Industry

The structure governing the linkages between alumina-bauxite operations, and alumina-primary aluminum operations represents an important planning and strategic decision for CVG-Aluminum. This chapter examines on a general level the issues concerning the integration between bauxite mining and alumina refining, and the integration of primary aluminum and alumina operations. This discussion lays down the issues to define what should be the optimal degree of vertical integration across the alumina industry.

3.1. Integration Between Bauxite Mining and Alumina Refining.

Non-homogeneity and highly imperfect markets are characteristics for bauxite. Refineries depend on particular bauxites, implying high switching costs in changing from one bauxite to another. Therefore, mines and refineries are dependent on each other in long-term relationships. In addition, bauxite is a low value product whose transportation costs represent a high proportion, approximately 50%, of its cif price. The interrelationship between mine and refiner due to bauxite internal properties favors a refinery location close to the mine supplier.

The mutual dependence of miner and refiner and their close physical location need not necessarily lead to bauxite-alumina vertical integration. They could be independent entities, with their transactions governed by long-term contracts. However, this condition represents a bilateral monopoly bargaining situation, in which neither buyer nor seller has any other rational alternative.[47] The pricing terms of contracts are indeterminate, and even when concluded by negotiations, would tend to break down as external conditions change. No matter how comprehensive the contractual terms, the contracts would always be

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[47] F. M. Scherer, Industrial Market Structure and Economic Performance, (Second Edition), Rand McNally College, 1980.

incomplete. As a consequence, bauxite transactions, in general, are internalized between the mine and the refinery by internal transfer prices, and there is no reason to believe that this will change in the future.[48]

But vertical integration has not eliminated the need to place a value on bauxite, for which no single free-market price exists. The reason is basically the scale mismatch between mines and refineries. In the 1960's and 1970's huge bauxite deposits were developed in Australia, Guinea and Brazil.[49] These mines still dominate the world bauxite supply. If developed as vertically integrated projects, each of these mines would have required the construction of between two to four large refineries to process their output. The capital costs and risks of such a venture would deter all but the largest companies.

The solution to this scale mismatch was the formation of joint ventures of several companies to develop the mines and take bauxite in proportion to their ownership to feed their own refineries needs, still a form of vertical integration. This form of organization ensured an outlet for the bauxite, and an assured supply of bauxite for the refineries enabling the joint venture partners to share the costs and risks of development.[50] It did not, however, avoid the problem of bilateral monopoly. Long term contracts were still necessary because mines ownership does not necessarily correspond to output shares by the partners,[51] potential conflict over contractual prices, or the destination of the bauxite; and host governments were concerned about the establishment of "fair" bauxite prices for taxation purposes.

Arguments for vertical integration recognize the strong mutual dependence between mines and refiners, and the extreme difficulty of setting bauxite prices. Long-term bauxite

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48 John A. Stuckey, Vertical Integration and Joint Ventures in the Aluminum Industry, (Cambridge, MA., Harvard University Press), 1983.

49 Shearson-Lehman-Hutton, Annual Review of the World Aluminum Industry, (1989), pp. 41-48.

50 Ibid .

51 John A. Stuckey, Vertical Integration and Joint Ventures in the Aluminum Industry, (Cambridge, MA., Harvard University Press), 1983.

contracts are a second-best solution. For example, Japan used to be a major purchaser of traded bauxites from the Pacific Rim, from Weipa and Gove, Bintan and Malaysia. The collapse of Japanese refining has left the mines at minimal operation,[52] and due to the impact of freight costs, it is difficult for these bauxites to compete in North America or Europe.

Because of the superiority of vertical integration between mines and refineries, most of the probable refinery expansions in the medium term are expected to be governed by a vertical structure. The traded bauxite market is likely to shrink. For example, a major buyer, CVG-AL, is building its own mine. CVRD, a major seller, is building its own refinery. Expansion of Australian refineries are also probable. The problems of mutual dependence are not all producer-oriented; the remaining bauxite buyers in Europe and North America must face the problem of their increasing dependence on a few sources of bauxite, mainly Boke in Guinea, in a declining bauxite market.

Vertical integration is therefore the best form of organization between mines and refineries, and may be inevitable in cases where freight costs reduce the possibility of exporting bauxite, such as in Western Australia. If there is no vertical integration, the strength of mutual dependence is such that transactions will almost always be governed by long-term contracts. These are the second-best solutions for bauxite transactions because of the scale mismatch between modern mines and refineries. Joint venture arrangements were a response to this mismatch, but the problems of enforcing long-term contracts have forced companies to internalize bauxite transactions. As a result, most refinery expansions and new refineries likely will be part of a vertically integrated system.[53]

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52 CVG-Planificación Corporativa data base.

53 Ibid.

3.2. Should Primary and Alumina Operations be Fully Integrated?

It is assumed that the firm is already integrated, and any change to its current state, even if desirable, will happen slowly.[54] One reason why structural changes might not be necessary is that alumina operations are competitive in their own right. If integration resulted from undertaking profitable alumina investments per se, in principle there would be no need to change. However, if changes are required, they will be slowed down by the high barriers to exit from the alumina industry.

The Integrated Majors' existing pattern of integration across the alumina market was not accidental, but resulted from a necessity to integrate backward because alumina markets did not exist. A characteristic for the Majors is their long alumina position, as a group they run a substantial alumina surplus. Therefore, they all produce enough alumina to supply their integrated smelting operations, plus a surplus to cover most of the Independent Smelters and Second-Tier Producers alumina deficit.[55]

The Miner/Refiners group is long in alumina, although its capacity did not grow in the same proportion as that of Independent Smelters. This is mainly because of the large minimum efficient scale required for greenfield alumina refineries, the need for access to low-cost bauxite sources, and the high risks associated with alumina investment. Thus, the Majors' alumina position is the one that complements the Independent Smelters' short position.

CVG-AL, classified as Independent Smelter mainly in response to historical developments, currently falls between the Miners/Refiners and the Independent Smelters. Its long alumina position and clear competitive advantage in energy locate CVG-AL in a contradictory situation at this point. Its access to cheap energy resources should provide incentive to CVG-AL to concentrate its investment plans in primary aluminum production

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54 John A. Stuckey, Vertical Integration and Joint Ventures in the Aluminum Industry, (Cambridge, MA., Harvard University Press), 1983.

55 Colin Pratt, "Is Vertical Integration in Aluminum Really Necessary?", Prepared for: Metals Week's Second Aluminum Symposium, 1989, pp. 4.

and run a short alumina position.[56] Currently, CVG-AL's operating costs in alumina are above average, while its primary aluminum production costs are among the lowest in the industry.[57] Although it is expected that CVG-AL alumina operating costs will be reduced as the Los Pijiguaos mines start producing efficiently, is it necessary to be fully integrated across its alumina operations?

As discussed previously, there is a growing alumina free-market, and the risk of supply shortage should decline due to the increasing size of the market and the number of buyers and sellers. Moreover, there is still high alumina price volatility and time lags between alumina and primary aluminum prices, thus alumina to primary aluminum relationship tends to be even more volatile. However, these sources of risk should be well managed by a low cost smelter. If a long alumina position is fully justified on cost grounds, revenues from increasing alumina capacity should be compared with potential revenues from increasing primary aluminum capacity because, in general, alumina revenues account for only a small proportion of total revenues.

Another consideration is that once an alumina investment is undertaken, exit from ongoing operations will not be easy due to high fixed costs, backward ties to bauxite either through mine ownership or long-term bauxite contracts, and especially, in the case of a state-owned enterprise, the social and political implications. Given these facts, exit from alumina operations only occurs in extreme conditions. In addition, because increases in alumina capacity are required to be large scale, any potential firm entering the industry, or any existing firm considering expanding its current capacity, must evaluate the impact of its own move on the prices of alumina.

Therefore, a fully vertical integrated organization between alumina and primary aluminum operations might not be the optimal decision. If there is no balance between alumina and primary operations, and the firm has clear cost advantages in its primary

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[56] This is assuming the development of the alumina free-market.
[57] Venalum C.A. data base.

aluminum operations, then the possible risks associated with running a short alumina position can be managed by structuring an efficient portfolio of contracts. Even if the firm's alumina expansion can be justified on cost grounds, access to low energy sources would force the firm to concentrate its expansion plans in the smelting stage.

Chapter 4
Cost Structure Analysis

This chapter analyzes the cost structure for the alumina industry and provides a base case estimate for a greenfield alumina refinery with the capacity of one million tons per year. This estimate is to be used as a base case for the valuation model presented in Chapter 6. It is based on cost data from the United States Bureau of Mines, and adjusted by data provided by Venalum C.A. The analysis is divided into three sections: capital costs, where the discussion is focussed on analyzing the capital outlays required for greenfield projects; operating costs which present an average operating cost scenario; and finally, the main operating cost: bauxite, caustic soda, labor and energy are studied on a company and a regional basis.

4.1. Capital Costs.

A capital cost estimate of $800 per ton of alumina is detailed in Table 9.[58] It is expected to be an average estimate of the actual cost for a greenfield project with a capacity of one million tons per year of alumina. Although the actual costs for a specific project will vary from this estimate, it serves as a base case for analyzing capital investments in the alumina industry. The actual cost of a refinery will vary depending on the infrastructure needs and the rated capacity on the equipment.

Equipment costs for the process are based on cost-capacity data and manufacturer's costs quotations. To cover minor construction costs and equipment not listed explicitly, a 10% contingency is added in each section. The field indirect costs for each section are

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[58] Deborah Kramer and Frank A. Peters, Cost Estimate of the Bayer Process for Producing Alumina, based on 1982 equipment prices. (Bureau of Mines-Department of Interior, IC-8958, 1983). The estimate is updated using information from Venalum C.A.

estimated as 10% of the direct cost.[59] Included under plant facilities, estimated at 8% of fixed capital costs, are the costs of material and labor for auxiliary buildings and the cost of non-process equipment. Also included are labor and material costs for site preparation. Plant utilities, including the cost of water, power, and steam are estimated at 10% of fixed capital costs.

Table 9. Capital Costs Estimate, 1989.

	($'000)
Fixed Capital:	
Bauxite Handling and slurry preparation section	34,856
Digestion section	94,132
Clarification section	73,564
Precipitation and decomposition section	112,475
Caustic regeneration section	241,545
Steamplant	30,730
Sub-Total	587,302
Plant facilities, 8% of above sub-total	46,984
Plant utilities, 10% of above sub-total	58,730
Total plant cost	693,016
Land cost	0
Sub-total	693,016
Interest during construction period	50,990
Total fixed capital cost	744,006
Working Capital:	
Raw materials and supplies	12,000
Product and in-process inventory	23,550
Accounts receivables	18,500
Desired cash	5,000
Working capital cost	59,050
Capitalized start-up costs	8,200
Sub-total	67,250
Total capital costs	811,256

Source: Deborah Kramer, Cost Estimate of the Bayer Process for Producing Alumina, based on 1982 equipment prices, (IC-8958, Department of Interior, Bureau of Mines, 1983): 6. The estimate is updated using information from Venalum C.A.

[59] This estimate includes field supervision, inspection, temporary construction, and equipment rentals.

The cost of interest on capital borrowed for construction is included as interest during construction. A 70% debt-to-equity ratio at the end of the construction period and 10% cost of debt, with no debt repayment during construction, are assumed.[60] Interests during construction are calculated as follows: interest for half of the new loan amount every year, plus full amount of previous outstanding debt. Land costs and port facilities are not included in this estimate. Working capital is estimated as follows: raw materials and supplies inventory for two months of operation, typical in the alumina industry , product and in-process inventory, accounts receivable assuming 30 days receivables,[61] and required cash. One percent of the fixed capital is estimated for capitalized start-up costs.

In greenfield projects, capital costs will vary considerably, depending upon the different infrastructure requirements, location, size and availability of local labor and materials. Although difficult to generalize, total capital costs for new refineries are currently in the range of $700 to $1,200 per ton of alumina installed capacity.[62]

The annual debt-servicing costs associated with such projects will vary according to the size of the initial investment, construction period, and the financial arrangements employed: debt to equity ratio, cost of debt, loan repayment period, assumed project cost of capital, and a variety of tax considerations. Table 10 shows the annual debt service for projects with different fixed capital costs, assuming a 10% cost of debt, and repayment periods of 10, 15 and 20 years. A constant debt to equity ratio of 70% is assumed and the debt repayment is calculated as an annuity. Even though this is not precise, it will give a sense of the debt service for alumina projects.[63]

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60 A 70% debt-to equity ratio is high if compared to aluminum companies' ratio at an average of 20-30%; however, it is usually the case on this type of investment to have such a high debt due to its high interest coverage ratio over the life of the project.

61 Days receivables is defined as accounts receivables over sales per day.

62 Frank X. McCawley, and Luke H. Baumgardner, Aluminum, Bureau of Mines, Preprint from Bulletin 675, Mineral Facts and Problems, 1985 Edition.

63 Investment cost is defined as the sum of fixed capital costs, interest during construction, and working capital needs at the end of the construction period.

Table 10 indicates that even in the case of low-cost projects depreciated over 20 years, capital charges could amount to $50 per ton of output. It also shows that for projects exceeding $1,000 per ton of capacity, annual debt service is around or in excess of $100 per ton depending on the amortization period. This example illustrates the high impact debt service payments could have on the project's cash flows. Operating costs will be analyzed in the next section.

Table 10. Annual Debt Service Estimates ($ millions).

		Repayment Period (Years)		
Total Investment	Debt Portion	10	15	20
600	420	68.35	55.22	49.33
800	560	91.14	73.63	65.78
1,000	700	113.92	92.03	82.22
1,200	840	136.71	110.44	98.67

4.2. Operating Costs.

Table 11 provides an estimate for raw material requirements per ton of alumina using bauxite from the "Los Pijiguaos" mine in Venezuela.[64] Table 12 provides an estimate for average operating costs per year. Both tables are based on Interalumina C.A.'s financial operating costs.[65]

The operating costs are divided into direct and indirect costs. Direct costs include raw materials, utilities, direct labor, plant maintenance, and operating supplies. The raw material costs, except for bauxite, are fob prices. Electricity, water and gas utilities are based on market prices.

64 Venalum C.A. data base.

65 In this case, the difference between financial and economic costs is not significant given that bauxite, caustic soda, replacement materials, and energy are quoted at market prices. Also, the sum of these costs accounts for more than 85% of total operating costs.

Table 11. Raw Materials Requirements per ton of alumina.

Bauxite[66]	2.340	ton
Caustic Soda (100%)[67]	0.140	ton
Limestone	0.010	ton
Starch	0.007	ton
Water	3.500	m^3
Electricity	230.000	Kwh
Natural Gas	222.000	NM^3

Source: Venezolana de Aluminio, Venalum C.A.

Table 12. Operating Costs Estimate, 1989.

	Annual Cost ($'000)	Cost per ton ($)
Direct Costs:		
Raw Materials:		
Bauxite at $34.6 per ton	80,960	80.96
Caustic Soda at $210 per ton	29,600	29.26
Limestone at $1.65 per ton	1,330	1.33
Starch at $170 per ton	760	0.76
Others	300	0.30
Sub-total	112,610	112.61
Utilities:		
Electricity at $0.015 per Kwh	3,450	3.45
Natural Gas at $0.038 per NM3	8,440	8.44
Industrial Water at $0.05 per m3	500	0.05
Sub-total	11,940	11.94
Direct Labor at $8.40 per hour	9,700	9.70
Plant Maintenance	7,250	7.25
Operating Supplies (10% of plant maintenance)	730	0.73
Indirect costs (40% of labor and maintenance)	6,780	6.78
Sub-total	24,460	24.46
Total Operating Costs	149,010	149.01

Source: Deborah Kramer, Cost Estimate of the Bayer Process for Producing Alumina, based on 1982 equipment prices, (IC-8958, Department of Interior, Bureau of Mines, 1983): 8.[68] The estimate is adjusted using information from Venalum C.A.

Plant maintenance is estimated separately considering: maintenance labor, maintenance materials, inventory adjustments, rental equipment, and other maintenance

66 Considering bauxite from the Los Pijiguaos mine in Venezuela.

67 It is obtained in liquid form (50%). One ton of Caustic Soda (100%) requires 2.58 tons of Caustic Soda (50%). From Interalumina C.A. data base.

68 Fixed Costs were excluded from the table provided by the source.

services. The cost of operating supplies is estimated as 10% of the cost of plant maintenance. Indirect costs are estimated to be 40% of the direct labor costs, plus maintenance costs. Indirect costs include expenses for control laboratories, accounting, plant protection and safety, plant administration, marketing, and company overhead. Research and overall company administrative costs outside the plant are excluded here.

The estimated annual operating cost for the base case is about $150 million or $150 per ton of alumina. This estimate is very sensitive to changes in the cost of bauxite, caustic soda, labor and energy. Special infrastructure requirements which depend on the individual plant site, have not been considered in this estimate. To estimate the significance of infrastructure cost, each project must be considered individually; thus making an estimate would be very misleading. In order to understand the factors affecting the main operating costs bauxite, caustic soda, labor and energy are each discussed separately in the next section.

4.3. Major Operating Costs.

The objective of this section is to present a comparative analysis of major alumina operating costs: bauxite, caustic soda, labor and energy, and determine the sources of competitive advantage that CVG-Aluminum might have in producing alumina. This analysis presents a cost distribution by companies and regions.[69]

4.3.1. Distribution by Major Companies.

Comparing CVG with other major alumina producers as shown in Figure 12, CVG currently has an average position. This is largely because of high bauxite cost.[70] It represents more than 50% of CVG's operating costs, and reflects the dependence on

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[69] The regional division is based on that used by the International Primary Aluminum Institute [IPAI].

[70] Interalumina C.A. had contracts for 1989 at $34.6 per ton of bauxite. This represents, on average, $76.8 per ton of alumina.

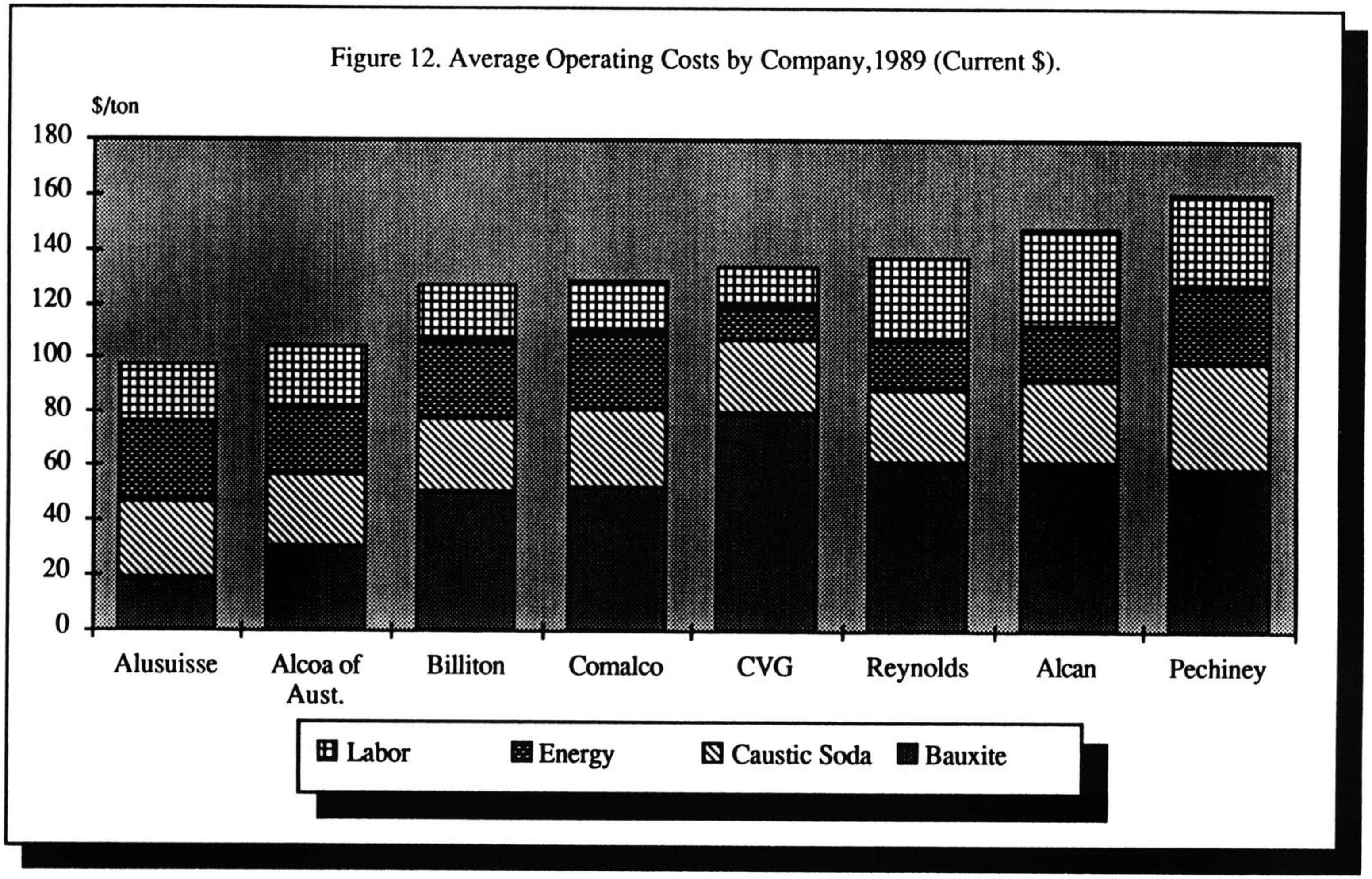

Figure 12. Average Operating Costs by Company, 1989 (Current $).

Source: Venezolana de Aluminio, Venalum C.A.

expensive imported bauxite, primarily from Trombetas, Brazil. CVG bauxite costs are expected to decline in the short term as the "Los Pijiguaos" mine comes fully on stream. Costs are expected to be at about $25 per ton cif considerably improving CVG's position.

This cost is on the optimistic side. High investment costs and time delays already incurred by the mine might force prices to be increased. Also, this expected price assumes an efficient transportation system along the Orinoco River which, has yet to be solved. So, if the bauxite cost to be used in the valuation should reflect real opportunity costs and not a subsidized transfer pricing policy, we would expect that the bauxite costs would be approximately $30 per ton of bauxite, or $67.2 per ton of alumina, assuming that 2.34 tons of bauxite are required per ton of alumina. If the latter is true, CVG's position would still be that of an average alumina producer with no real competitive advantage in increasing its capacity.

Other important points are notable from Figure 12: The low operating costs of Alcoa of Australia and Alusuisse would make these companies the most likely to increase their alumina refinery capacities, given the possibility they have to expand their ongoing refineries. In addition, Alusuisse has the best technology for alumina operations. Pechiney and Alcan have the highest operating costs in the industry. As the free market continues to expand, we would expect Alcan and Pechiney to rely more on the arm-length market. This situation may open new opportunities for existing low-cost producers or for new entrants.

4.3.2. Distribution by Regions.

The following sections consider each of the major operating costs and describe the average cost by region. It presents the average cost in 1988 and 1989 in current U.S. dollars, and a personal estimate of what the trend might be in the short term. A consolidated view of the major operating costs is shown in Figure 18.

4.3.2.1. Bauxite Costs.

Trends in bauxite capacity and markets can be viewed as evolutionary rather than subject to the cyclical swings which have characterized primary aluminum, and more specifically alumina. Since 1960, bauxite production has steadily shifted from industrial countries to less developed countries, except for the case of Australia, whose output is mostly refined into alumina.[71]

The pattern of bauxite production is not expected to change through the 1990's. It will continue shifting from industrial countries to less developed ones. Guinea and Jamaica should remain as major producers, and growth in output is expected in Brazil and Venezuela to cover their domestic primary aluminum production fully.[72]

In analyzing bauxite prices it is important to differentiate between refineries which form part of an integrated mining operation, and those which rely on imported bauxite. At many integrated mines bauxite prices depend upon the adopted internal transfer pricing policy. For those bauxites traded on a free market, such as in Western Australia, India and Brazil, bauxite is priced on the basis of the prevailing market prices.

Bauxite prices vary considerably, from as low as $6 per ton at integrated mines to as high as $35 per ton for Boke material. To a large extent, this wide spread in prices reflects quality differences between the various bauxites. Proximity to the consuming refinery also affects freight rate differentials and therefore ultimately has an impact on prices. Government-imposed levies or export taxes are other factors to be considered when comparing different bauxite prices.[73]

To compare different bauxite types, it is necessary to consider prices in terms of the recoverable alumina content of each material. Indeed, bauxites with similar fob or cif prices could be valued entirely differently by refineries due to wide variations in the alumina

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71 The World Bank, Price Prospects for Major Primary Commodities, 1988-2000, (Washington D.C., The World Bank, 1989).

72 Ibid.

73 Venalum C.A. data base.

content of each bauxite. It is therefore important to obtain a standardized bauxite price which takes account of the available alumina content of the ore. The amount of bauxite required per ton of alumina varies, depending on the sourcing mine, ranging from 1.95 tons to almost 3.5 tons of bauxite per ton of alumina.

Figure 13 shows the prices of imported bauxite into the United States relative to imported alumina contract prices. Here we can see a close correlation between bauxite and alumina prices. However, when compared to aluminum prices, there are clear time lags between alumina and primary aluminum prices created by the adjustment time required by the alumina and bauxite contracts. Indeed, both markets are mainly contractual markets with few spot transactions.[74]

Figure 14 shows weighted average bauxite costs in U.S. dollars per ton of alumina for 1988-1989, and a medium term, speculative tendency. This accounts for refineries' bauxite arrangements, specifications and prices cif.[75] As the figure shows, Oceania has the lowest bauxite cost by a considerable margin, primarily as a result of low operating costs and integrated mining operations. Also, Australian refineries are closer to their bauxite source of supply, excluding the case of QAL.[76] Of all the Australian refineries, Gove enjoyed the lowest bauxite cost at around $14 per ton of alumina in 1989. The QAL refinery had the highest bauxite cost of any refinery in the region, over $45 per ton of alumina in 1989. This was due mainly to the transfer policy of Weipa bauxite to the refinery at a market price rather than on a cost basis.[77] The plant also incurred considerable freight charges on the long distance from the mine to the refinery. In future years average

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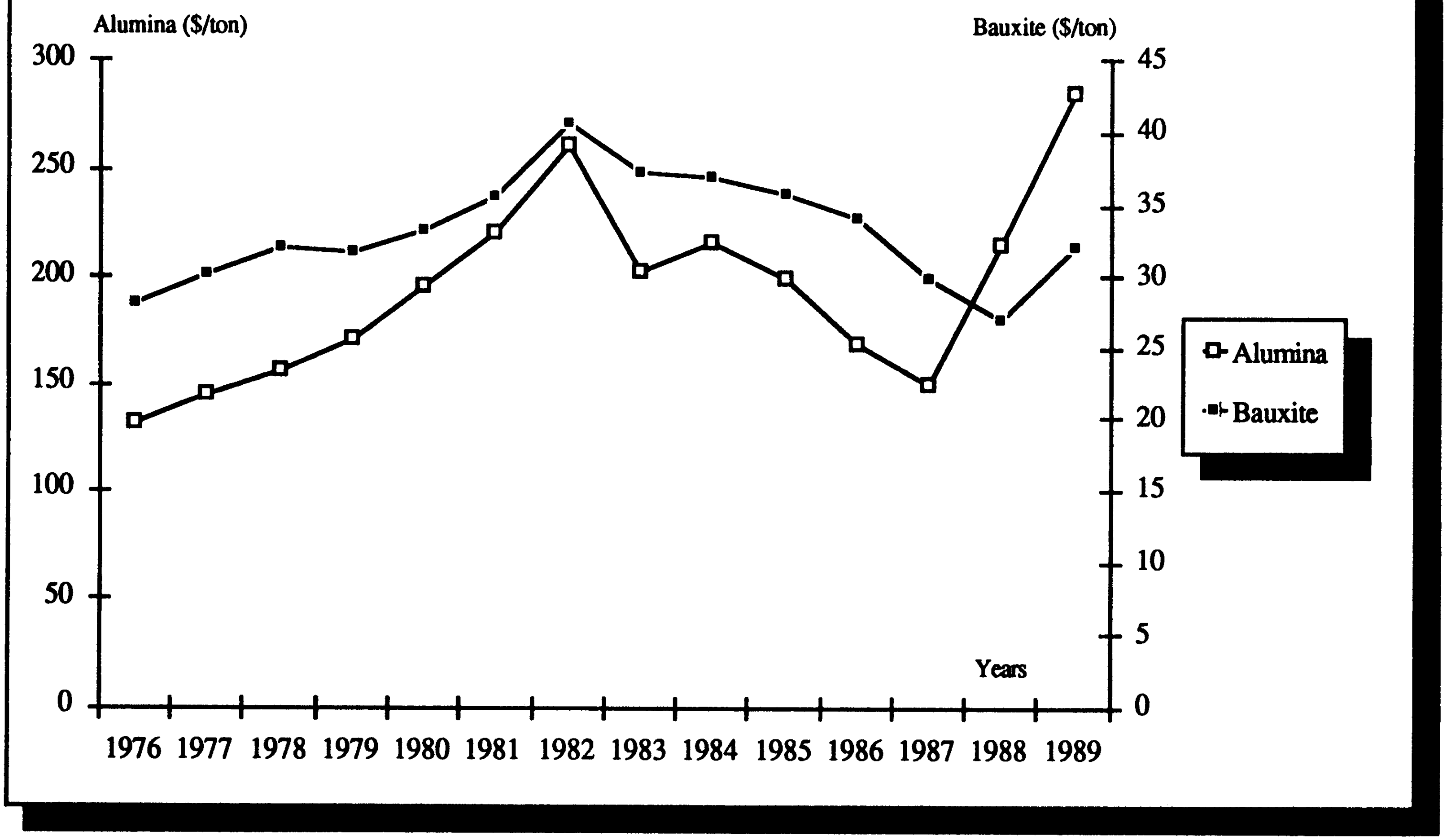
74 Ibid.

75 Ibid.

76 Queensland Alumina Limited, Australia.

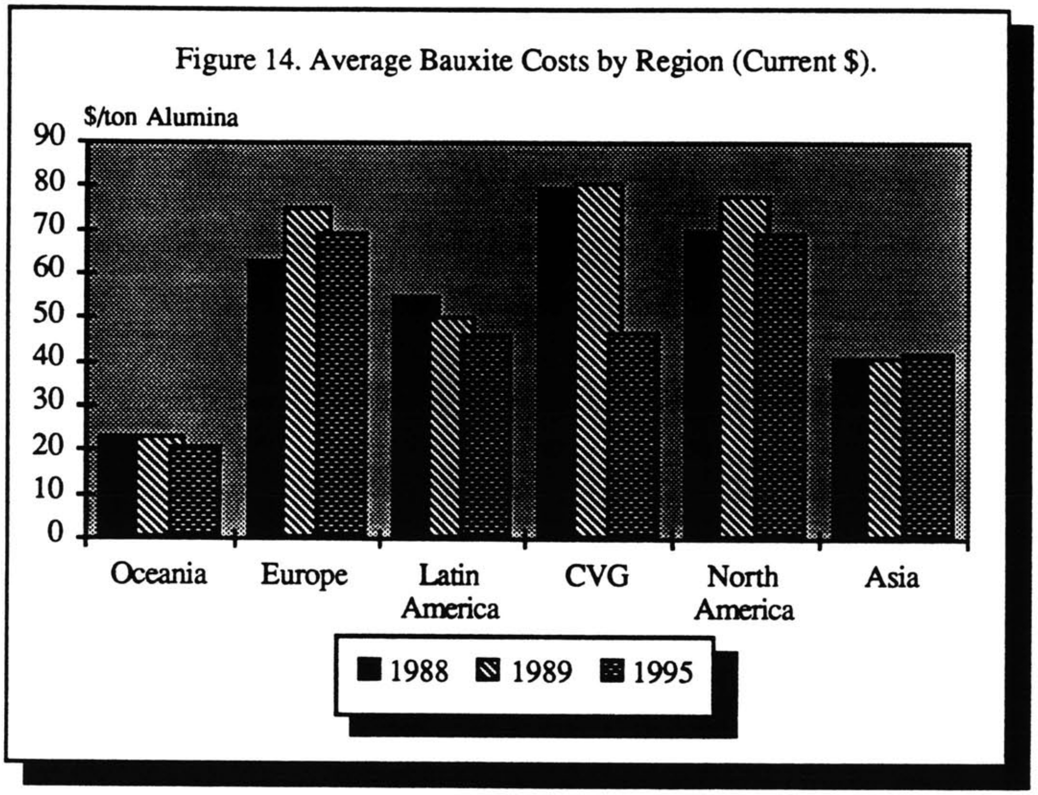
77 Venalum C.A. data base.

Figure 13. Prices of Alumina and Bauxite imported into US (Current $).



Source: Venezolana de Aluminio, Venalum C.A.

bauxite costs in Australia are set to decline in real terms, largely as a result of the Australian Dollar falling in value with respect to the U.S. Dollar.[78]



Source: Venezolana de Aluminio, Venalum CA.

Asia ranks second among regions in terms of low bauxite costs, a ranking which reflects the close relationship of adjacent mines-refineries in the area. Indeed, all India's alumina capacity is fed by local bauxites.[79] Over the next few years, the price is expected to remain constant in real terms in the region.[80]

Despite access to large local supplies, Latin American refineries must pay comparatively high bauxite prices due to high transportation costs, especially in Brazil and

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78 The World Bank, Price Prospects for Major Primary Commodities, 1988-2000, (Washington D.C., The World Bank, 1989).

79 Venalum C.A. data base.

80 The World Bank, Price Prospects for Major Primary Commodities, 1988-2000, (Washington D.C., The World Bank, 1989).

Venezuela, and the impact of the Jamaican bauxite levy. Another factor putting upward pressure on average prices has been the poor operating performance of the Los Pijiguaos mine in Venezuela. A series of delays from Los Pijiguaos have forced CVG to depend greatly on imported bauxite at a cost of approximately $80 per ton of alumina. However, expected improvement in Los Pijiguaos's operations, a projected fall in Trombetas bauxite price, and a decline on the Jamaican bauxite levy should ultimately result in a lower average bauxite price for the region.

Bauxite costs are far higher in Europe due to the fact that most of the bauxite consumed is imported at market prices, plus the cost of transportation from the producing region. Indeed, European producers with local supplies had bauxite costs well below average in 1989. European bauxite costs rose in 1989 when Guinean [Boke] bauxite prices increased. Boke bauxite accounts for most of the bauxite consumed in Europe. But this high bauxite cost is likely to decline after 1989 as a result of declining prices in alumina and primary aluminum markets.[81]

Bauxite costs in North America are currently the highest in the world, because of the unavailability of local bauxite supplies. North American refineries must thus depend fully on expensive, traded bauxites, which as noted earlier have high transportation costs. U.S. bauxite costs will tend to remain constant over the next few years.

4.3.2.2. Caustic Soda Costs.

Caustic soda costs come from two sources, chemical losses and physical losses. In 1989, chemical losses varied from as low as 17 kg per ton of alumina in refineries running solely bauxite from the Boke mine, to as high as 128 kg per ton on refineries running high-reactive-silica-content bauxites. Physical losses can range from as low as 20 kg per ton to

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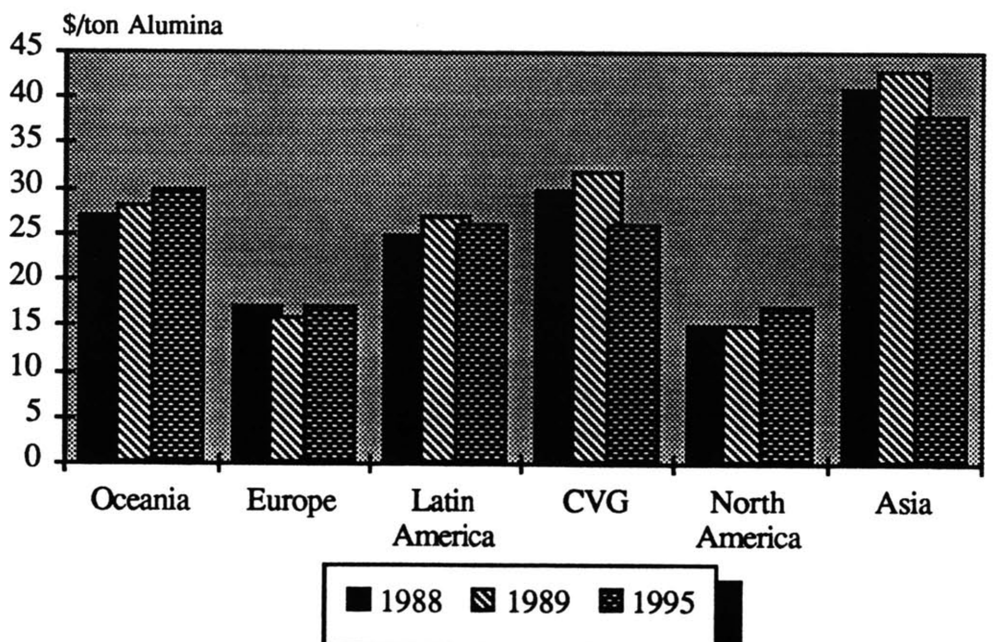
81 Ibid.

as high as 50 kg per ton of alumina. Thus, total caustic soda losses can vary from a low of 37 kg per ton to a high of 148 kg per ton of alumina.

Between 1986-1989 caustic soda prices increased, and they are expected to continue increasing, largely as a result of a tight chlorine market. From the refineries' perspective, costs of caustic soda represent, approximately 20% of full operating cost, the third highest cost behind bauxite (37%), and energy (25%).

Figure 15 shows the distribution of caustic soda costs per region in U.S. dollars per ton of alumina. North American caustic soda costs average the lowest in the world and are expected to remain low throughout the next several years, a reflection of North American access to low soda prices and the consumption of high-cost, low-reactive-silica bauxites.

Figure 15. Average Caustic Soda by Region (Current $).



Source: Venezolana de Aluminio, Venalum CA.

Caustic soda costs are relatively low in Europe for similar reasons. The high amount of Boke bauxite consumed in European refineries should help to ensure that caustic soda costs remain at their 1989 level for the next several years. However, those refineries consuming European bauxites will continue to have high caustic soda costs.

In Latin America, the cost of caustic soda has not risen as steeply as elsewhere in recent years, mainly because Brazilian caustic soda prices were already at extremely high levels prior to 1986.[82] Over the next few years, Latin America caustic soda costs are expected to remain close to today's level. However, because of high reliance on the spot market, the region may still be vulnerable to the high short-term volatility of the market.

Costs are much higher in Oceania due to the proportionately greater reactive silica content of Australian bauxites. In the last two years the cost of caustic soda has risen by more than 200%.[83] This sharp rise in caustic soda prices has reduced the operating costs gap between Australian and the rest of world refineries.

Due to the exceptionally high level of domestic prices in India, Asia experiences the highest caustic soda costs. Although some decline is expected in real terms for the future, it is expected that Asia will continue to maintain the highest costs in the industry.

4.3.2.3. Labor Costs.

On average, labor costs account for approximately 15% of total direct operating costs, and varies considerably depending on different regional labor productivity ratios and employment costs. Figure 16 shows labor cost distribution in U.S. dollars per ton of alumina.

Labor costs in North America and Europe are considerably higher than those in other regions as a result of higher minimum wages. Indian labor costs are the lowest, despite poor productivity, because of extremely low employment costs and a depreciated

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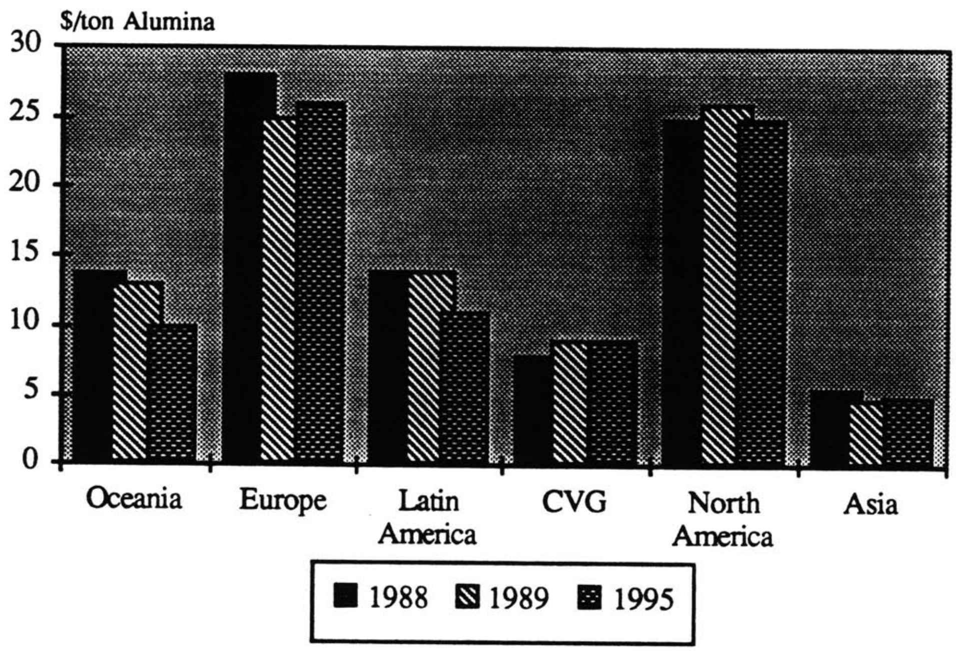
82 Venalum C.A. data base.

83 Ibid.

currency. In general, the higher average productivity of North American and European refineries is insufficient compensation for the lower wages of the less developed countries. An exception is Australia, where productivity is high and labor cost half way between developed and developing countries[84]. By 1995, Oceania and Latin America are expected to increase their labor-competitive advantage due to major brownfield expansions and currency depreciation against the dollar.

Figure 16. Average Labor Costs by Region (Current $).



Source: Venezolana de Aluminio, Venalum CA.

4.3.2.4. Energy Costs.

Energy costs represent 20-25% of total operating costs. Of all operating costs, energy costs have decreased the most due to technological improvements in alumina

[84] Ibid.

refining.[85] Refineries differ markedly, however, in terms of energy efficiency and fuel costs. CVG's refinery is one of the lowest energy cost refineries in the world, with energy costs at about 8% of total operating costs. Indian refineries have the highest energy costs, accounting for almost 50% of total direct production costs. These illustrate the wide variations between energy costs when considering refineries' relative cost position.

Figure 17 shows average energy cost distribution by region on U.S. dollars per ton of alumina[86]. North America has the lowest energy costs in the industry. Relatively low, energy-consumption technology and more importantly, access to cheap gas supplies, provide North America with a clear competitive advantage over other regions. This advantage is expected to remain, though it is likely to diminish as the other low-energy cost regions, Australia and Latin America, begin to close the gap, as a result of U.S. dollar appreciation.

Latin America has relatively low energy costs, estimated at about $26 per ton of alumina in 1989. However, the region's average cost is significantly affected by the low energy costs incurred at CVG's refinery. This efficient refinery has extremely inexpensive gas supplies, with energy costs at about $12 per ton of alumina. Most other refineries in the region are dependent on expensive heavy fuel oil.

Costs in Oceania are relatively low, at about $32 per ton on average in 1989, due in part to the region's accessibility to local gas supplies. A decline is expected in the future due to the U.S. dollar appreciation.

Due to higher average fuel oil prices, energy costs in Europe are relatively high compared to other regions. In 1989, the average was about $45 per ton. It is expected that high energy costs will remain in the region unless new, cost-effective technological improvements increase refineries' efficiency.

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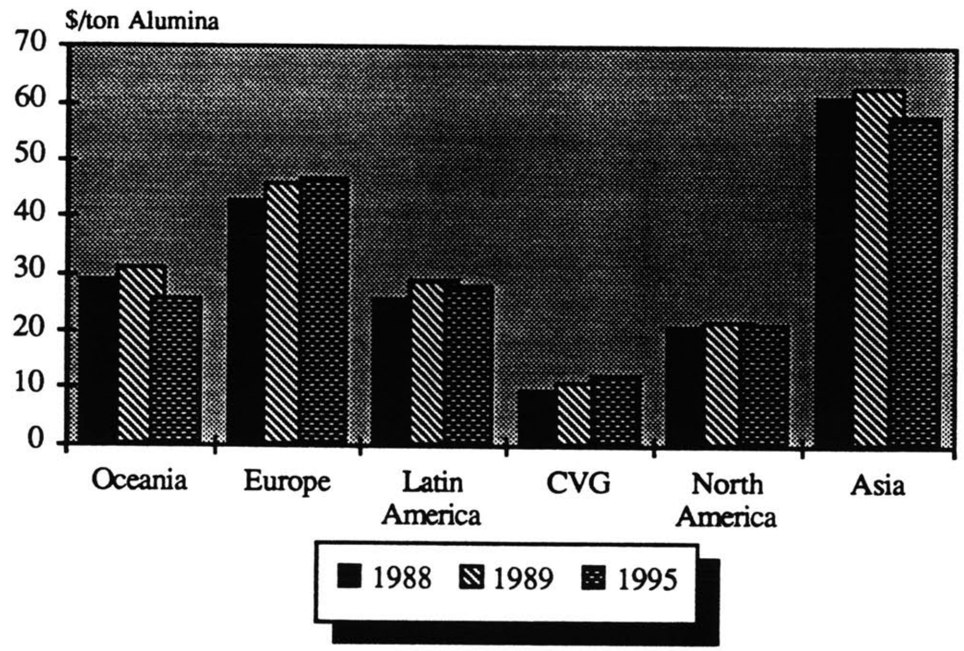
85 Ibid.
86 Ibid.

Asia's costs are the least cost-competitive, at an average of $63 per ton due to high fuel prices and high energy consuming refineries. Although Asia's costs are expected to fall as a result of the installation of new energy-efficient technology and a depreciating exchange rate in India, it will have very little effect on Asia's position as the highest energy cost region.

Figure 17. Average Energy Costs by Region (Current $).

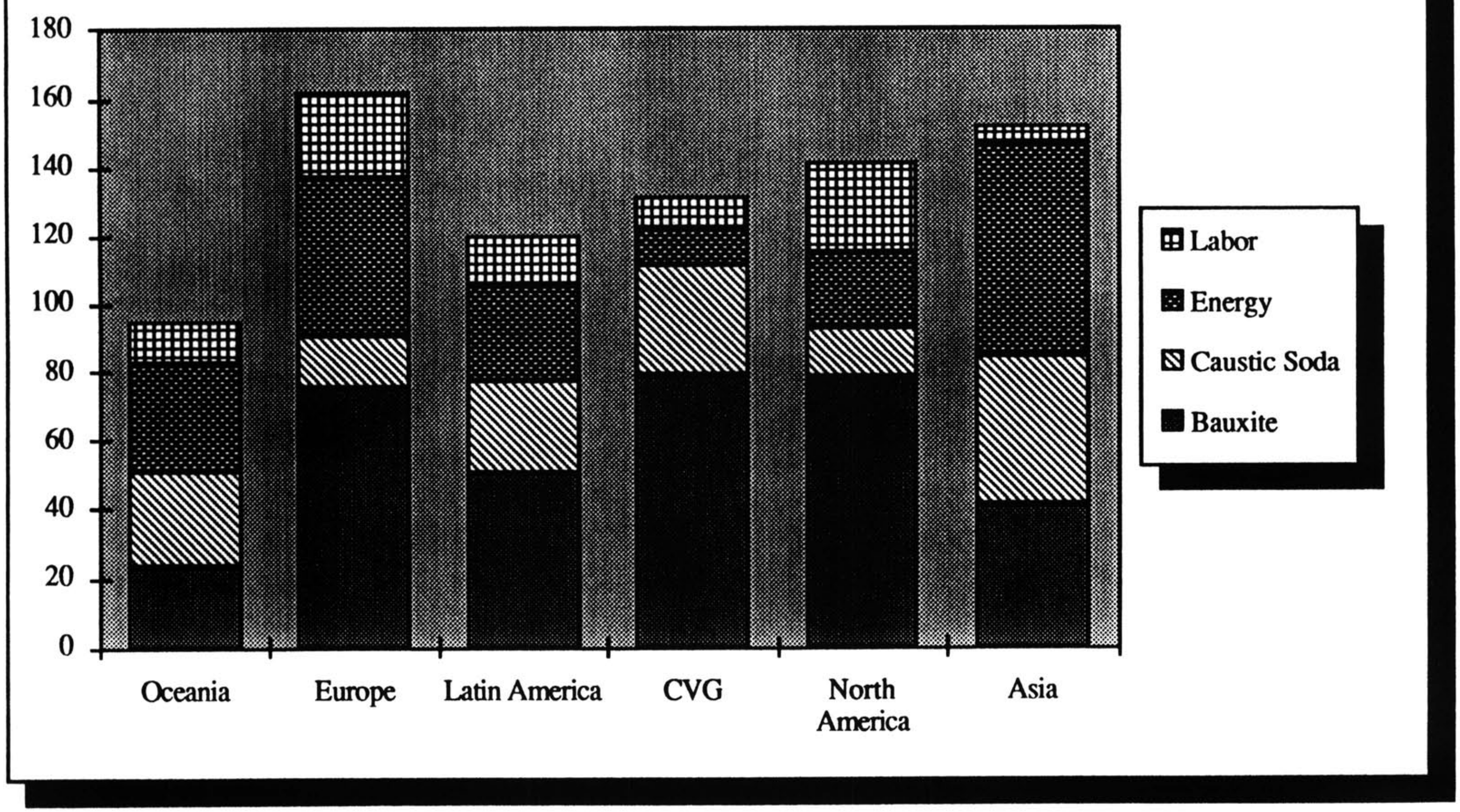


Source: Venezolana de Aluminio, Venalum CA.

4.3.2.5. Consolidated Distribution by Regions.

Figure 18 shows the 1989 consolidated cost structure by region, including major operating costs, expressed in U.S. dollars per ton of alumina. It is important to note the variability of bauxite and energy costs, which both account for more than 60% of the total in all regions. The foregoing facts show that the sources of competitive advantage in alumina production stem from access to low-cost energy and bauxite.

Figure 18. Consolidated Cost Distribution by Regions, 1989.



Source: Venezolana de Aluminio, Venalum C.A.

Finally, even though CVG has access to low cost labor and energy resources, its extremely high bauxite costs place the company above the Latin American average. This clearly shows the necessity for improving production at the Los Pijiguaos mine as the only viable alternative for reducing bauxite costs. Otherwise, the refinery requirements would have to continue being covered by actual suppliers due to the dependence between mines and refineries. Given the imperfections of the bauxite market and its tendency to shrink, imported bauxite would be expensive and difficult to find.[87]

This brings us to the issue of what the CVG strategy should be, and to what extent an alumina expansion should be considered at this point, given the many uncertainties associated with the domestic bauxite production.

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[87] The World Bank, Price Prospects for Major Primary Commodities, 1988-2000, (Washington D.C., The World Bank, 1989).

Chapter 5
Organization of the Alumina Industry

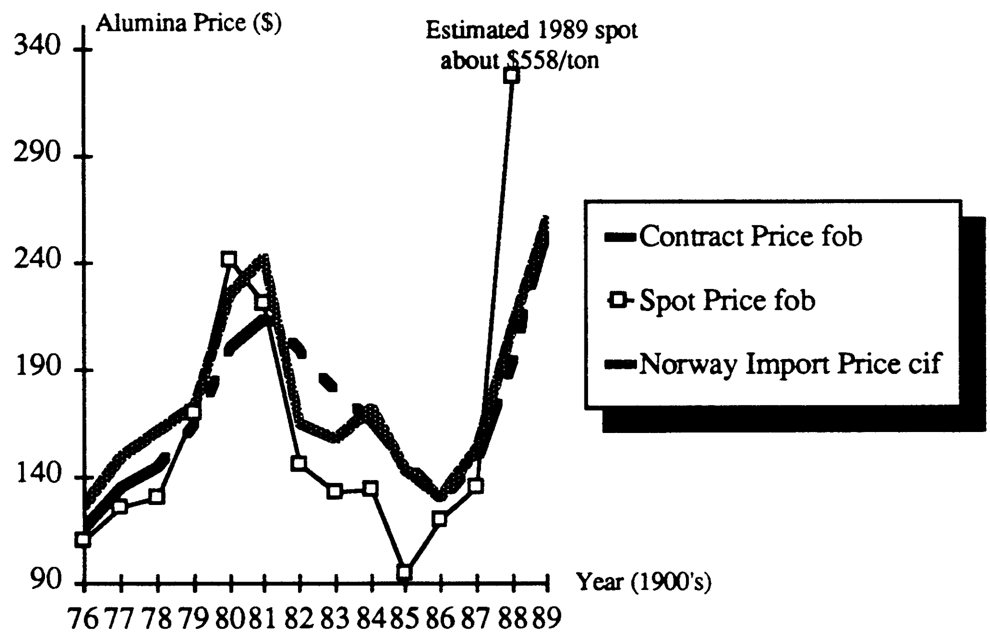
This chapter examines the underlying structure of the alumina market and its behavior, analyzes factors that affect alumina prices, and evaluates the impact of expanding capacity in the industry. Two models: perfect competition and oligopoly are analyzed to shed light on what is the underlying organization of the industry, and how this organization might affect prices. The supply and demand curves derived for this purpose represent a first approximation. The methodology used does not consider any dynamic interaction over time. To include any dynamic relationship, sophisticated econometrics and forecasting methods are required, which are beyond the scope of this thesis. Nevertheless, this rather simplified approximation is very helpful in understanding alumina pricing.

5.1. Past Trends in Contract and Spot Prices.

Figure 19 shows the pattern of alumina spot and contract prices since 1976. The prices shown are average values, except for Norway cif import prices. This figure refers to estimated medium term, two-to-five-year contracts negotiated on an fob basis. Norway cif prices are shown because its alumina requirements are fully covered by arm-length transactions. Norway cif prices give a good approximation of the market response to changes in industry conditions.

In contrast to the primary market, there is no recognized reference cycle for the alumina free-market. At any particular period there is a wide range of contract prices which vary according to different factors, such as duration of the contract, relative location of the supplier, quantity contracted, and the relationship between the parties concerned. Furthermore, there is significant variations in individual contract prices, not only between those quoted by different alumina producers, but also between prices quoted by the same alumina producer.[88]

Figure 19. FOB Contract and Spot Alumina Prices ($/ton).



Source: Industria Venezolana de Aluminio, Venalum C.A.

Despite these qualifications, Figure 19 clearly shows a dramatic decline in alumina contract prices since the early 1980's. After rising to nearly $245 per ton in 1980, average fob, medium term contract prices subsequently fell to around $130-145 per ton in 1986-1987 respectively, representing a 40% reduction in six years. This was followed by an unexpectedly large increase in average alumina prices in the last two years when spot prices rose, on average, to above $500 per ton at the peak in 1989, and contract prices rose to $260 per ton of alumina fob. This was mainly caused by a tight alumina balance as result of an increased demand for primary aluminum.[89] After a steady increase in prices from 1976

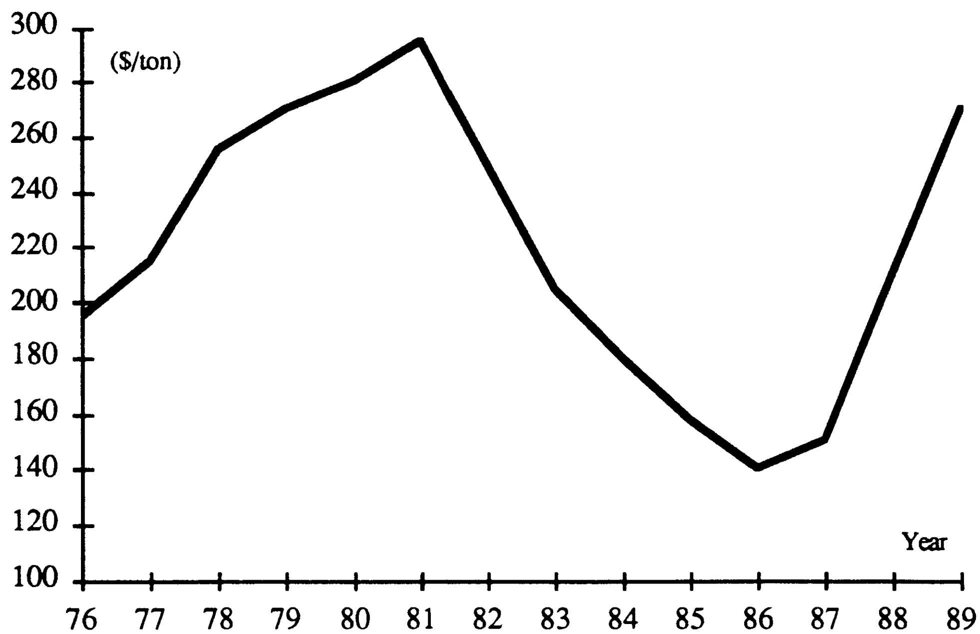
88 Venezolana de Aluminio, Venalum C.A.

89 Ibid.

to 1981, the decline in real prices was even more pronounced, as is evident from Figure 20. Indeed, in real terms the average delivered price fell by almost 60% between 1981 and 1987.

Of special interest is the relationship between recent movements in free-market alumina prices relative to the LME three-month price index.[90] Alumina-to-primary-aluminum exchange ratios are essentially the inverse of prices expressed in terms of some percentage of primary prices. Usually, the ratio specified in the contract will depend upon a variety of arrangements, current primary aluminum prices, and in particular, whether the alumina and metal price are determined on a cif or an fob basis.[91]

Figure 20. Trends in Real Alumina Prices (1989$).



Source: Venezolana de Aluminio, Venalum CA.

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[90] LME: London Metal Exchange Index. It varies depending on the duration, e.g., cash, three-month, etc.

[91] Interview with Mr. Antonio Azpurua. Venalum-International Officer.

It is apparent in Figure 21, that apart from 1980-1982 and 1988-1989, when alumina prices moved far out of line with primary aluminum prices, the alumina to primary prices tended to fluctuate within 0.085 to 0.12. Finally, after rapid revival of primary prices in 1987, the ratio increased suddenly during 1988 and 1989. In these two years, the spot alumina to LME-three-month primary aluminum price ratio reflected the unexpected increase in aluminum demand. Primary prices were above normal levels at approximately 110¢/lb in 1988 and 90¢/lb in 1989.

5.2. Structural Changes and their Influence on Pricing Policies.

The alumina market has undergone considerable changes over the past decade. During the 1970's the industry was characterized by high levels of refinery utilization, well in excess of 80% throughout most of the period, strong demand growth, and a high degree of vertical integration.[92] Also, Alcoa of Australia has been, by far, the largest supplier of the alumina free-market.[93] Under these conditions, long term, cost-based, contracts were commonplace and comparatively little business was conducted on a short term, 1-to-3 year contracts or spot basis. Uncertainty about possible shortage of raw materials in the 1980's only served to reinforce the need for securing long term supply agreements.[94]

By the early 1980's the basic structure of the alumina market began to change dramatically, and was accompanied by a radical shift in pricing policies. Several factors were responsible for these changes: overcapacity began to emerge in the 1980's, initially the result of a sharp slow down in alumina demand during 1981 and 1982, and later exacerbated by the introduction of new refining capacity in Australia, Latin America and

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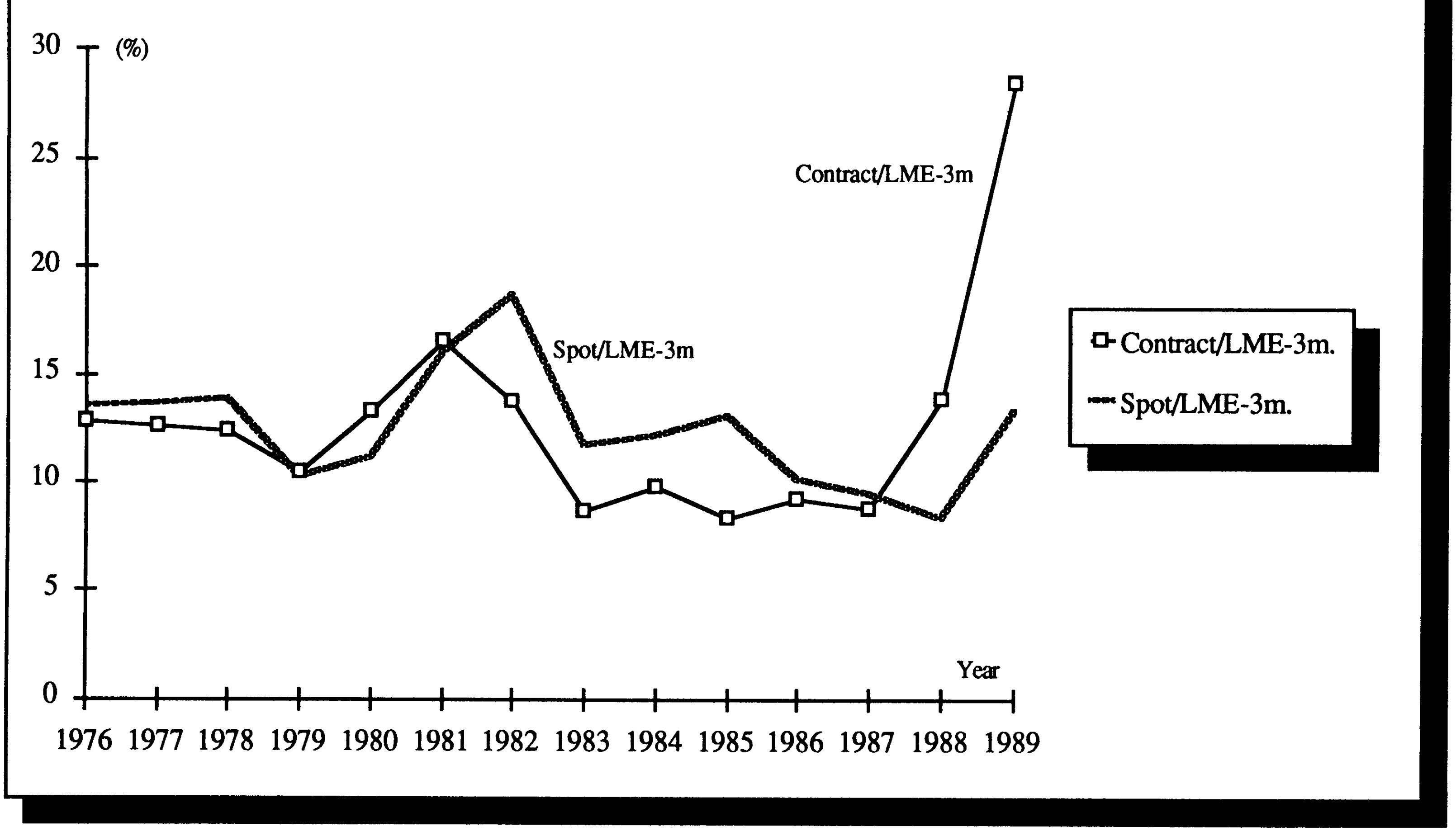
92 Shearson-Lehman-Hutton, Annual Review of the World Aluminum, (1989), pp.41-48.

93 George D. Smith, From Monopoly to Competition: the Transformation of Alcoa, 1888-1986, (Cambridge University Press, 1988).

94 Robin Adams, "Economic Cost Analysis of the Aluminum Industry", as part of "The Metal Bulletin's Fifth International Aluminum Conference," Caracas, Venezuela, 1988.

Figure 21. Alumina Price to LME-3 months Price.



Source: Venezolana de Aluminio, Venalum C.A.

Ireland.[95] Over capacity in the alumina market, along with decreased demand for primary aluminum demand and weak prices, forced independent smelters to impose considerable pressure on alumina producers to renegotiate their supply arrangements. Consequently, contract-time lengths became shorter, particularly for new contracts.

Although long-term supply agreements still persisted, the period between price negotiations was often reduced significantly to avoid prices moving too far off line from the free-market, and contract terms were renegotiated with traditional cost-based clauses, including escalation terms based, partially or fully, on primary prices.[96] As a result, the negotiating power balance clearly shifted towards free-market alumina buyers. The emergence of additional free-market alumina sellers undoubtedly contributed to these changes.

By getting assurances for their minimum quantity under existing long-term contracts, many smelters were able to take advantage of this growing availability of free-market alumina by increasing their spot purchases. This helped to maintain the demand pressure on prices during the mid-1980's. More importantly perhaps, integrated transfer prices and production policies began to reflect the extreme weakness of the alumina free-market. The traditional cost based approach to transfer pricing policy tended to be replaced by pricing policies which closely reflected free-market prices.

The increasing size of the alumina free market over the past decade has shifted the alumina market to a "quasi-commodity" market behavior.[97] However, the market cannot be considered perfectly competitive, due to the existence of market rigidities and high concentration levels in the industry, and the maintenance of high cost refineries by major companies such as Pechiney. These facts reflect not only the importance of optimal economic decisions, but also the importance of strategic and institutional considerations.

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[95] Venalum C.A. data base.

[96] Ibid.

[97] A 'quasi-commodity" market exists when prices are expected to be ultimately governed by competitive forces

Technical factors also affect the speed of supply response since capacity changes are often made in large steps to achieve minimum efficient scale. Moreover, few producers continue to dominate the free-market and long term contracts still exist.[98] Quality considerations, as well, can affect supply relationships although, with greater standardization in alumina specifications, this barrier to free-market transactions has tended to disappear.

In order to understand the structure that might prevail in the industry, it is important to analyze the behavior of the free market. In the next section the models of a perfectly competitive market and of an oligopolistic market are considered to explain the behavior of the alumina market. The latter is studied, assuming the existence of a dominant firm.

5.3. The Alumina Free Market Behavior.

The aim of this section is to analyze the models of perfect competition and oligopoly as possible explanations to the underlying alumina free-market organization. We will also study other factors affecting prices, such as regional imbalances, primary aluminum prices, and primary aluminum-alumina ratios.

5.3.1. The Free-Market Supply and Demand Curves.

Before studying either of the two models, it is necessary to define alumina free-market supply and demand.[99] It can be argued that, in the short term, integrated producers will often continue to operate their refineries simply in order to supply the alumina requirements to their own smelting system. Production decisions made by these companies will be influenced not only by commercial considerations, but also by strategic and

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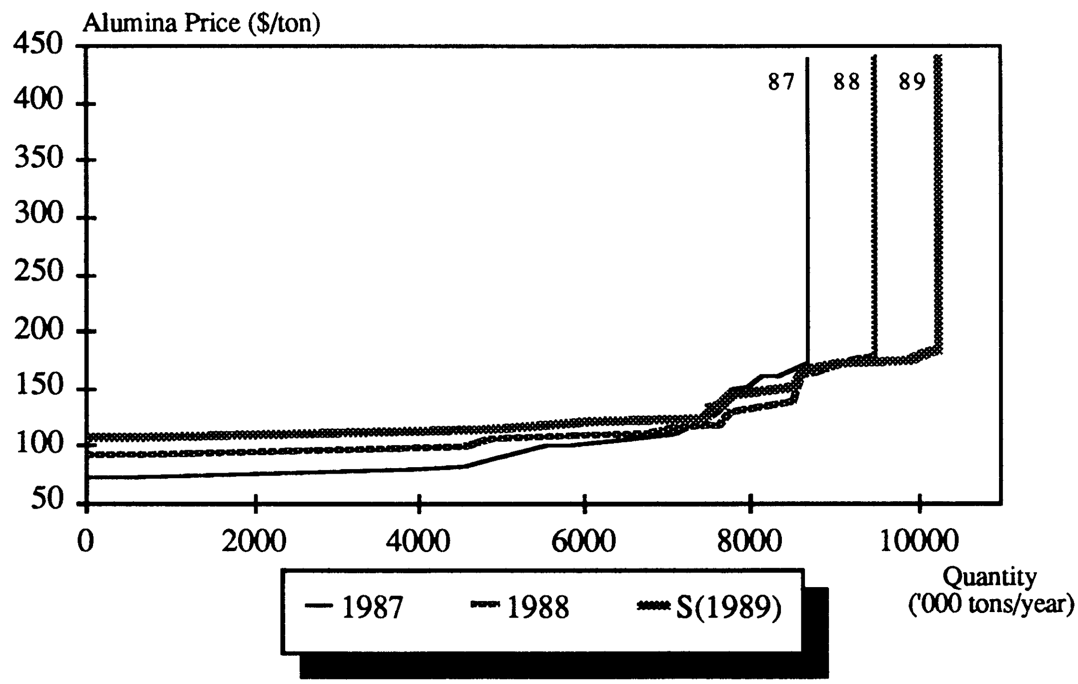
98 Mike Edwards, "Structural Change in the Alumina Market", Metals Week Aluminum Symposium, 1988.

99 The free market is analyzed in order to have a good approximation of the market price. The objective is to avoid considering any distortions which might have been created by internal transfer pricing policies.

institutional factors. Consequently, some integrated refineries may continue to operate in the short term even though they are failing to cover their operating costs at prevailing market prices.

Figure 22 depicts the derived free-market supply curves for 1987, 1988 and 1989. The supply curve has shifted upwards because of changes in current operating costs due to inflation. Shifts to the right represent increasing available capacity to the free market. It is important to note that new capacity has always been on the flat part of the curve, which has increased the elastic portion of the supply curve.

Figure 22. Estimated Free-Market Supply Curves, 1987-1989 (Current $).



Source: Venozolana de Aluminio, Venalum C.A.

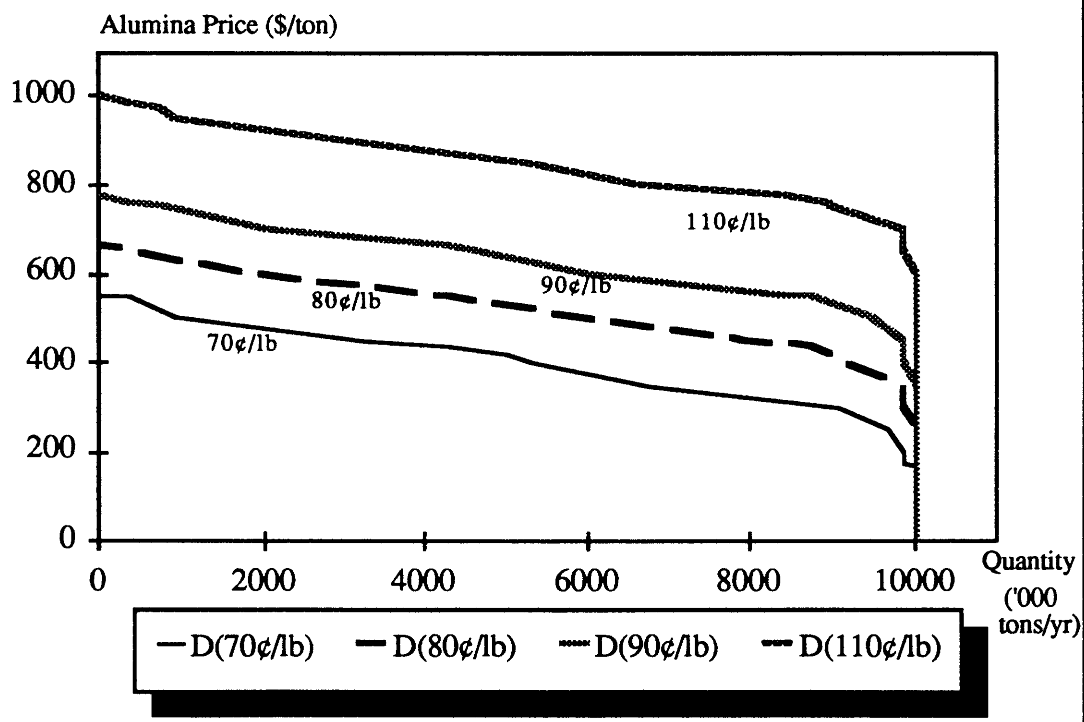
Supply schedules have been derived by examining available output for non-integrated transactions.[100] A certain degree of approximation is necessary to plot such

100 Venalum C.A. data base.

curves to avoid taking into account integrated supply arrangements which, for the purpose of evaluating potential free-market supplies, should be excluded. The free-market capacity available in 1987 was about 8.6 million tons just over 9 million tons per year in 1988, and about 10.2 million tons per year in 1989.

Figure 23 shows the derived demands for hypothetical primary aluminum prices of 70¢/lb, 80¢/lb, 90¢/lb and 110¢/lb using 1989 smelters' operating costs.[101] The free-market demand is represented by a curve which plots smelters' willingness to pay, given their operating costs, excluding alumina for a given primary price.

Figure 23. Derived Demand Using 1989 Operating Costs.



Source: Venezolana de Aluminio, Venalum C.A.

The derived demand curves define the quantity required by non-integrated smelters at different alumina prices. In cases where smelters obtained alumina from both integrated

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[101] Venalum C.A. data base.

refineries and the free market, only free-market supplies are included.[102] The ability to pay for alumina was then derived by subtracting operating cost estimates for a given aluminum price and deducting an alumina freight cost to obtain an fob measure of smelters' willingness to pay[103]. Total aluminum capacity dependent on the free alumina market accounted for about 5.2 million tons in 1989. The major buyers of free-market alumina are producers in the Middle East, Hydro Aluminum in Norway, Alumax and the newly formed independent smelters in the United States [U.S.]. Others include Aluar in Argentina, Albras in Brazil, Asahan in Indonesia, and Delfzijl in Holland.[104]

5.3.2. Perfectly Competitive Pricing Model.

In perfect competition, producers are price takers and price is determined where the industry's marginal cost equals the industry's marginal revenue. Consequently, on the basis of this rather simple model, price movements can be caused by shifts in either the supply or the demand curve.[105] Certainly the pronounced downward shift in costs during the 1980's helps to at least partly explain the fall in prices which occurred over this period.[106] Indeed, between 1982 and 1987 full production costs at the marginal alumina supplier fell by some $60 per ton in nominal terms, while contract alumina prices declined by $40 to $50 per ton on average.[107]

In a highly competitive environment with large surpluses saturating the market, prices can be driven down to a point where the marginal supplier is only covering its

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102 Those supplied under long-term agreements were excluded.
103 Freight costs were assumed constant at $10.
104 Venalum C.A. data base.
105 Robert S. Pindyck and Daniel L. Rubinfield, Microeconomics, (Macmillan, 1989).
106 Costs had a downward shift mainly as result of technology improvements and the location of new refineries in low-cost regions.
107 Venalum C.A. data base.

average costs, especially if complete production shutdown involves large costs[108] and/or withdrawal from strategically important sectors in the industry. Producers may then continue to operate in order to supply an integrated smelting system, maintain market share, or because they assume that weak prices will be temporary.

Figure 24 depicts the market equilibrium for different primary aluminum prices. In this case, the supply and demand curves for 1989 derived in Figures 22 and 23 are used. Market equilibrium is defined as the price and quantity at which marginal cost equals marginal revenue, i.e., where the supply curve is equal to the demand curve. The equilibrium outcome will depend on the chosen primary aluminum price. Hence, it is important to examine the consequences of changing primary prices on the derived demand for alumina, and see how the equilibrium result changes.

For primary aluminum prices of 80¢/lb, 90¢/lb and 110¢/lb, the equilibrium price is about $200 per ton of alumina fob and the equilibrium quantity, approximately 10 million tons of alumina per year. However, alumina contract prices in 1989 were, at about $275 per ton.[109] This difference in price reflected the tight market and the risk of possible supply shortage. In the case where primary price is 60¢/lb, equilibrium quantity is lower at about 9.2 million tons per year. But, interestingly, the equilibrium price does not change. This situation is similar to what happened during 1982-1987, when the market was in a surplus position and contracts were priced at approximately competitive equilibrium levels.

One implication that arises from this non-linear situation is that there is no simple relationship between alumina and primary prices. When primary aluminum prices increase above 60¢/lb, increased alumina contract prices will not reflect the competitive equilibrium. The final price will depend mainly on contractual agreements, the negotiation power of the

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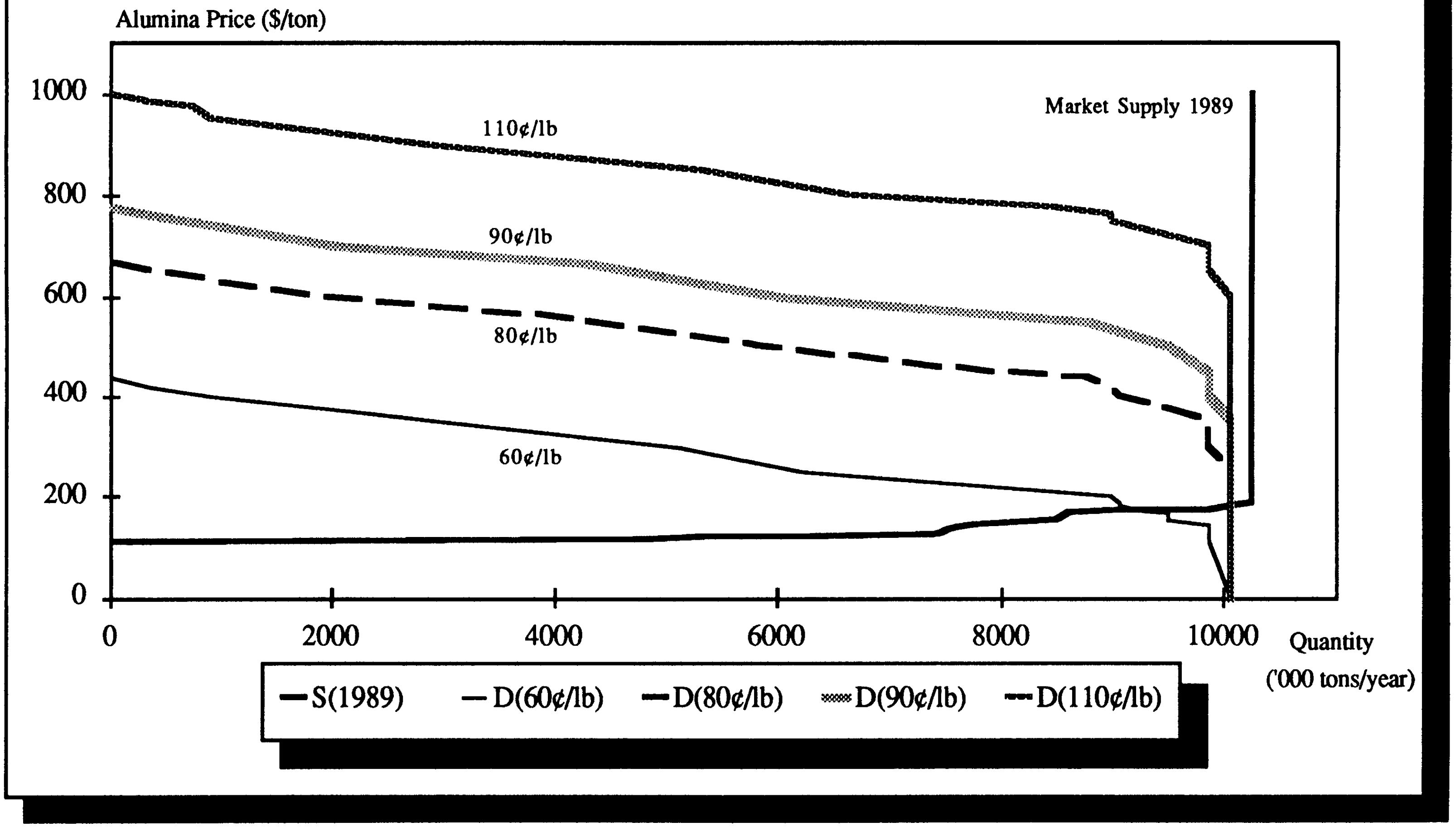
108 Not only financial costs have to be considered, but also, especially for state-owned enterprises, social and political costs to analyze management's decision to shut down production.

109 Venalum C.A. data base.

Figure 24. Perfect Competitive Market Equilibrium, 1989.



Source: Venezolana de Aluminio, Venalum C.A.

parties involved, and the ability of alumina producers to collude.[110] This accounts for the variation in contract prices, even for prices quoted by the same refinery selling to different smelters.[111] In contrast, when the primary aluminum price falls from 60¢/lb, alumina prices will mainly reflect competitive equilibria.

This asymmetric response to primary aluminum price arises because the cost structure of the market is not uniform: to the left of the intersection between D(60¢/lb) and the alumina supply curve, the marginal cost curve is flat, almost infinitely elastic; to the right, the alumina cost schedule rises quite steeply over a small range of production, thus becoming a quasi-inelastic supply. Also, above 60¢/lb metal prices, non-integrated alumina demand is close to its maximum attainable level. Hence, rising primary aluminum prices, causing the demand curve to move upwards, cannot push it beyond the maximum available production capacity, and assuming no change in alumina supply,[112] that will increase the supply shortage risk.

In conclusion, it is worth highlighting the following issues: a rise in the primary aluminum price above certain level will cause a rapid escalation in alumina price as smelters' demand rises. Because the alumina supply is a step function, small movements in the primary price around certain critical values may result in rapid change in alumina pricing, reflecting a high alumina price sensitivity to changes in capacity. A ceiling on the competitive alumina price occurs at about $200 per ton, reflecting the operating cost of the marginal supplier. As primary prices rise above 63¢/lb, demand for free-market alumina remains at 10.2 million tons per year. Demand is constrained by the smelting capacity available to purchase alumina and hence, higher primary aluminum prices will cease to exert upward pressure on the price of alumina. Given this situation and assuming an

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110 F. M. Scherer, Industrial Market Structure and Economic Performance, (Second Edition), Rand McNally College, 1980.

111 Venalum C.A. data base.

112 This is a reasonable assumption, given the slow response due to high barriers to entry and/or exit.

oligopolistic behavior, above 63¢/lb is where the dominant firm might be in a position to exercise market power. This behavior is discussed in the next section.

5.3.3. Oligopoly Pricing Model.

A second behavior to be considered is that driven by the oligopolistic organization of the industry. The analysis of free-market prices has been confined to the model of perfect competition, which takes the demand for alumina as given. While justifiable, this approach is rather restrictive and does not reflect the underlying oligopolistic structure of the industry.[113] Perfect competition may not always prevail in the alumina market, nor can demand be viewed as totally independent of the price of aluminum, as shown in Figure 23. The purpose of this section is to study the oligopolistic model so as to describe the behavior of the alumina free market. The approach considers the derived supply and demand curves for the alumina free market based on refineries' marginal costs and smelters' ability or willingness to pay for alumina at a given price of primary aluminum.

The objective is to investigate the applicability model of dominant behavior to the alumina industry and compare the outcome with the one assuming a perfect competitive organization. The theory of the dominant firm is particularly pertinent to the alumina market, where relatively few producers supply a large number of buyers. In these circumstances it is conceivable that one or more producers could try to cut back production and increase prices in order to exert market power.[114]

As previously stated, the supply side of the non-integrated alumina market is characterized by a relatively small number of producers. Here the model of perfect competition, based on the assumption of a large number of small producers, each taking

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[113] Alcoa has approximately 40% of the total free-market supply, according to Venalum C.A. data base.

[114] F. M. Scherer, Industrial Market Structure and Economic Performance, (Second Edition), Rand McNally College, 1980, and Robert S. Pindyck, and Daniel L. Rubinfield, Microeconomics, (Macmillan, 1989).

prices as given, may not be appropriate. Rather, a model which allows producers to alter production levels to influence price may be a more appropriate tool for analyzing the alumina market.

The framework is that of price leadership where one producer, the price leader, sets a price which other producers, the followers, take as given. Price is determined by the leader's adjusting optimal production. The leader first sets a marginal revenue equal to its marginal cost to achieve optimal production; then, for a given level of production, the price is set along its demand curve. The obvious candidate for the role of price leadership is Alcoa of Australia (AA), by far the largest supplier in the market.[115]

Figure 25 shows the oligopolistic equilibrium, assuming the 1989 derived supply and demand curves at a primary aluminum price of 90¢/lb.[116] If AA behaves as a price leader, its profits would be maximized by setting a price for alumina and adjusting production to sustain this set price, given the derived demand curve and operating costs of other producers. As Figure 25 shows, the optimal solution to the problem is for AA to set a price just under $200 per ton of alumina. This can be sustained if AA produces approximately four million tons per year.[117]

Average alumina contract prices in 1989 were about $275 per ton fob. The difference can be explained by the fact that the equilibrium outcome lies in the kinked area[118] of AA's demand [D(Alcoa)]. Therefore, prices are not going to reflect of equilibrium outcome; but the price at which, as perceived by AA, there is no incentive for new entrants to build new refineries, or for existing firms to expand their installed capacity. AA's market power will then depend on how responsive the market is to increases in

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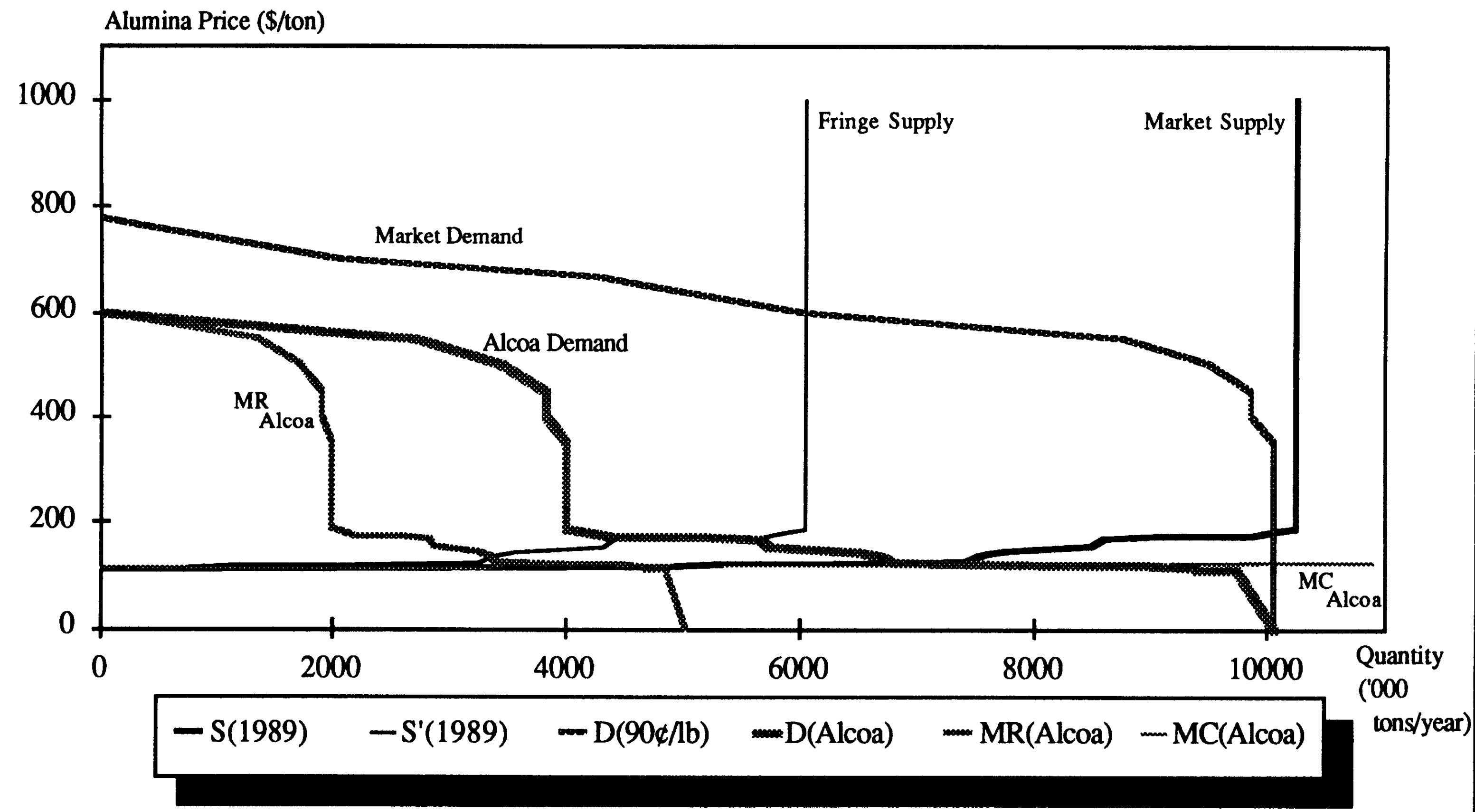
115 V.Y. Suslow, "Estimating Monopoly Behavior with Competitive Recycling: An Application to Alcoa", Rand Journal of Economics, 17 (Autumn 1986): 389-403. The percentage data if from Venalum C.A. AA accounts for about 41% of the total free-market supply.

116 It is assumed that the AA marginal cost curve lies between the market supply curve and the fringe supply curve.

117 Total free-market supply is about 4.8 million tons per year.

118 Kinked area refers to the area where there is a big jump in the demand curve.

Figure 25. Oligopolistic Equilibrium, 1989.



Source: Venezolana de Aluminio Venalum C.A.

contract prices. The greater the barriers to entry into the alumina market, the higher the price set by Alcoa will be. The capacity to increase prices also depends on how far the optimal solution lies in the kinked area, the different contractual agreements, and the capacity for the main alumina suppliers to collude.[119] Thus, the potential for boosting profits by restricting output is highly dependent on the position of the primary aluminum price and the alumina supply and demand balance.

On the other hand, at a low primary aluminum price, there is too much non-Alcoa available alumina capacity which could be brought into operation if AA decided to restrict output in an attempt to raise prices. Under a low price scenario, there is no incentive for AA to reduce output to affect alumina prices. In this case, industry output and the price level would be close to the perfect competitive equilibrium.

In general, the incentive for cutting back production to raise prices is greater when primary prices are high, the smelting sector is operating close to full capacity, and the alumina free-market balance is tight. However, if the price set by AA is perceived as an above-normal, long-run marginal price, other competitors may see it as an incentive to expand capacity, which would then drive prices down to competitive levels. Thus, AA's strategy would be expected to present a mixture of low and high alumina prices, depending on the perceived primary price and the parties concerned. This policy would enable AA to boost its profits by maintaining the balance of the alumina market. Otherwise, new capacity will shift the supply curve out, and prices will drop to marginal levels, which is exactly what happened in the mid-1980's.

5.4. Other Factors Influencing Prices.

In assessing the determinants of price and producers supply response to changing market conditions, it is important to take into account regional imbalances between alumina

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119 F. M. Scherer, Industrial Market Structure and Economic Performance, (Second Edition), Rand McNally College, 1980, (pp.169-227).

supply and demand, the relationship between alumina and primary aluminum prices, and primary aluminum price indices used in contractual agreements.

Regional imbalances and their impact on fob prices is especially true for Europe, where there is a large deficit of alumina and where the region is dependent, in general, upon supplies from Latin America and Australia.[120] Due to freight costs, it is logical that refineries in Latin America, facing the same fob price, will supply the United States East Coast first, long-term contracts permitting. Assuming the remaining surplus from Latin America is not sufficient to cover Europe's requirements, supplies from Australia are necessary. Despite the widespread use of swaps, physical deliveries from Western Australia are required in Europe, assuming European smelters work close to full capacity. In terms of sources of supply rather than costs, Australia can be considered the marginal supplier to Europe.

Australian refineries will then take the market as determined by the relationship between supply and demand as a reflection of the free-market environment in the short term. However, to be competitive on a cif basis, producers in Australia would normally be expected to achieve fob prices slightly lower than the next alternative supplier in Europe or Latin America due to freight cost differentials. Indeed, assuming a typical freight cost of $12 per ton from West Coast Australia to Western Europe, compared to $6 per ton from Ireland, producers in Europe should be able to attain fob prices $6 per ton higher than their Australian counterparts for the same type of contracts. Similar considerations apply to relative prices between producers in Latin America and Australia competing for business on the East Coast of the United States.

In reality, market imperfections rarely permit prices to be determined precisely in the way theory would suggest. In a tight alumina market such as that experienced during the past two years, independent European smelters have undoubtedly put pressure on

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[120] Shearson-Lehman-Hutton, Annual Review of the World Aluminum Industry, 1989, (pp. 41-48).

nearby suppliers to offer fob prices comparable to those of Australia. However, it is clear that to be competitive on a cif basis, European refineries would normally be expected to obtain slightly higher fob prices than those offered to Australian producers. For integrated European producers located adjacent to or near their smelters, the transfer price will bear a much closer relationship to the delivered price, since the former reflects the true opportunity cost to the smelter. Freight costs and regional unbalances are further factors that need to be taken into account when considering the relationship between costs, prices and production decisions[121].

Another factor that affects prices is the relationship between alumina and primary aluminum prices. In theory there is no simple, direct relationship as far as new contracts are concerned. The previous sections have shown that if a perfectly competitive market is assumed, prices will be driven up/down to the level of operating costs of the marginal supplier. However, if an oligopolistic market is assumed, prices will be set by the dominant firm in the industry.

The mechanism by which aluminum prices affect alumina contract prices is indirectly through shifts in the alumina-derived demand curve. In the absence of any fundamental change in the cost structure of the primary aluminum and/or alumina industries, higher prices will result in higher smelter output. Alumina demand is thereby increased, reducing the amount of surplus capacity available. Consequently, shifts in the demand for alumina brought about by movements in primary prices will change both the position and cost of the marginal refinery.[122]

Developments in the primary market can influence contract prices due to the relative bargaining position of refineries and independent smelters. When primary prices are high, there is less pressure on smelters to obtain the lowest alumina price possible. Smelters may

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121 James F. King, "Trends in the Economics of Bauxite and Alumina", Proceedings of Bauxite Symposium VI, 1986.

122 Ibid.

be willing to allow the refineries to share with them above normal profits to ensure security of supplies. In practice, minimum and maximum price limits protect both smelters and refineries from excessive primary aluminum price movements.

Finally, events of the past years have focused attention on which primary aluminum price should be used in contract escalation formulas.[123] Although primary prices have traditionally followed essentially the same pattern, price differentials between aluminum and alumina have changed considerably. Of particular interest to alumina refiners has been the extreme volatility of LME prices. Certainly producers who have secured contracts based on the three-month price have enjoyed more stable alumina prices than companies whose prices are based on cash quotations. Also, linking the base alumina price to other indexes would not guarantee any greater stability. In fact on a monthly basis, other price indexes such as U.S.-Mid-Western Merchant Price Index have fluctuated more widely than either of the LME three-month prices.[124]

Since the main objective is risk avoidance, it is perhaps more important for refiners to base their alumina contract on primary prices that closely match their realized selling prices. Although to achieve greater stability refiners may consider using a basket of prices index which might be less volatile than most other published market related primary indexes, they will adopt a primary price escalator consistent with their own particular attitudes towards risk-return and the region to which their alumina is supplied.

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[123] Escalation formulas refer to those formulas used to adjust prices if conditions change.
[124] Venalum C.A. data base.

Chapter 6
Alumina Refinery Valuation

The purpose of this chapter is to provide CVG with a decision-making instrument for appraising capital investment and strategic investment planning. A simulation model using a Net Present Value [NPV] approach is used to derive the valuation results of an alumina refinery with the capacity of one million tons per year in Venezuela. This model excludes option equivalents or terminal value cash flows so as to focus the analysis on the operating sources of value from the perspective of the equity holders.

6.1. Valuation Model.

This valuation studies the underlying economics of an alumina refinery plant and gives an approximation for its base Net Present Value [NPV].[125] The analysis does not consider values created by non-linearities such as: option equivalents, special financing arrangements or subsidies, tax holidays and/or tax loss carry-forwards, or government guarantees. A detailed valuation of an international project would have to incorporate these non-linearities which can be modeled with option pricing techniques.[126] Where the project has a clear, positive NPV, and is mutually exclusive within a set of alternatives, an explicit risk analysis should be performed to show not only the expected NPV outcome, but also the NPV probability distribution. The analysis includes depreciation tax shields assuming straight line depreciation over a 20-year period, and interest tax shields assuming a 36%

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125 Most of the data is based on the assumption that the project is to be built in Venezuela. However, the simulation model is sufficiently flexible to accommodate projects with different characteristics.

126 Option equivalents are cash flows that respond non-linearly to changes in some underlying cash flows or asset values. For further discussion, see Robert S. Pindyck, Irreversibility, Uncertainty, and Investment, (Massachusetts Institute of Technology, August, 1989), and Daniel Siegel, James L. Smith, and James L. Paddock, "Valuing Offshore Oil Properties with Option Pricing Models", Midland Corporate Finance Journal, (5)1, (Spring 1987).

corporate tax rate.[127] Even though this is a rather simplified approach, this framework generates a first approximation solution which can be used as an effective decision-making tool in studying the main economic variables for an alumina refinery project.

Modern finance theory provides us with a general equilibrium framework for the valuation of capital assets under uncertainty: the Capital Asset Pricing Model [CAPM][128]. Initially formulated in the context of perfect markets and one period projects, it has been extended to cover multiperiod projects.[129] The CAPM gives the theoretical foundations for the NPV investment decision rule.

For complex projects, where agents operate in imperfect, often incomplete and segmented capital markets, investment and financing decisions are not independent, therefore it is necessary to include in the analysis any value created by complex contractual or financial agreements. The NPV additivity principle will permit adding to the base NPV any value created by non-linearities in the project. The NPV approach provides present value estimates of cash flows to the different agents depending on their contractually agreed share of expected future cash flows. In this way, the efficiency of a contract structure and its risk allocation should be evaluated.[130] The usefulness of the NPV approach is the recognition of the sources of economic value accrued to various agents as a result of the financial structure.

The alumina refinery project is considered a stand-alone project whose cash flows are the collateral for long and short-term debt agreements. This is referred to as *project*

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127 CVG-Planificación Corporativa. Expected tax rate for new projects.

128 To review the model, see Michael C. Jensen, "Capital Markets: Theory and Evidence," The Bell Journal of Economics and Management Science, (3)2, (Autumn 1972): 357-398, and David W. Mullins, "Does the Capital Assets Pricing Model Work?," Harvard Business Review, (January-February, 1982).

129 Eugene F. Fama, "Risk-Adjusted Discount Rates and Capital Budgeting Theory under Uncertainty," Journal of Financial Economics, 5, (August 1977): 3-24.

130 Contract valuation is beyond the scope of this thesis. For reference, see Charles Blitzer, Donald R. Lessard, and James L. Paddock, "Risk Bearing and the Choice of Contract Forms for Oil Exploration and Development," report prepared for the Corporación Estatal Petrolera Ecuatoriana, MIT, Energy Lab, 1982.

financing , i.e. the "financing of a particular economic unit in which the lender is satisfied to look initially to the cash flows and earnings of that economic unit as the source of funds from which a loan will be repaid and to the assets of the economic unit as the collateral for the loan."[131]

The simulation model does the analysis from an equity point of view. To define each of the cash flow components for the valuation model, Interalumina C.A.'s 1986-1988 financial statements were first analyzed. The idea was to build the pro-formas for the project as if it were to be run by Interalumina C.A., a reasonable assumption given the company's competitive performance since it began operating in the mid-1970's. The free cash flows to equity are defined in Table 13.

Table 13. Free Cash Flows to Equity.

Net Income before dividends	
Plus:	Depreciation
Minus:	Change in Working Capital
	Capital Expenditures
	Debt Repayment
Plus:	Other income
	Other non-cash items deducted in the Income Statement

Source: Paul Asquith, class notes, and James L. Paddock, class notes.

The Capital Asset Pricing Model [CAPM] was used in defining the cost of capital to the equity components in the valuation. According to the CAPM, an appropriate risk-adjusted discount rate must include both the riskless rate of the interest and a risk premium, reflecting only the systematic risk of the cash flow. The discount rate therefore must depend on the systematic risk of alumina price revenues, operating cash flows, and the relevant portfolio of risky assets. It is assumed that CVG-AL operates internationally whose set of risky assets is the the world capital market. Since the U.S. capital market commands such a large proportion of the world market portfolio, the risk-free rate and the expected excess return on the market are based on the U.S. capital market.

131 Peter K. Nevitt, "Project Financing," Euromoney Publications, (London, 1979), p. 13.

For government participation, in this case represented by CVG-Aluminum, the discount rate estimates provided by the CAPM also represent a good approximation to its economic cost of equity capital. Assuming CVG-Aluminum does not have the required technical, financial and/or managerial expertise to carry on alumina development, it is likely they would have to sign service contracts.[132] Therefore, CVG-Aluminum participation, if not invested in the project, would be invested in comparatively international funds during the same period. Consequently, the discount rate for CVG-Aluminum's cash flow is the marginal cost of incremental funds invested in international capital markets, reflecting the systematic risk of the alumina project which is close to the discount rate obtained using the CAPM.

This assumption may be too restrictive, given the availability of domestic inputs such as energy, labor and bauxite. Energy is a non-tradeable good, which is currently priced in dollars at its long-run marginal costs, though closely reflecting its opportunity cost or economic price. The required labor would be rather specialized and therefore would be assumed as a mobile factor priced at market levels, except for some exchange rate distortions. Finally, while bauxite supplies are currently imported at $34.5 per ton, it is expected that the Los Pijiguaos mine will cover all Venezuelan bauxite requirements. It is beyond the scope of this thesis to analyze whether the Venezuelan bauxite can be sold internationally. Nevertheless, this is an important fact to be considered given that the project's bauxite cost should reflect the opportunity costs of using Los Pijiguaos's bauxite domestically instead of exporting it. As an approximation for the bauxite opportunity costs, the World Bank scenario of $25 per ton of bauxite in 1985 dollar terms is considered as the base case scenario[133] [see Figure 26]. This approximation coincides with Bauxiven's target of pricing its bauxite at $25 per ton cif.

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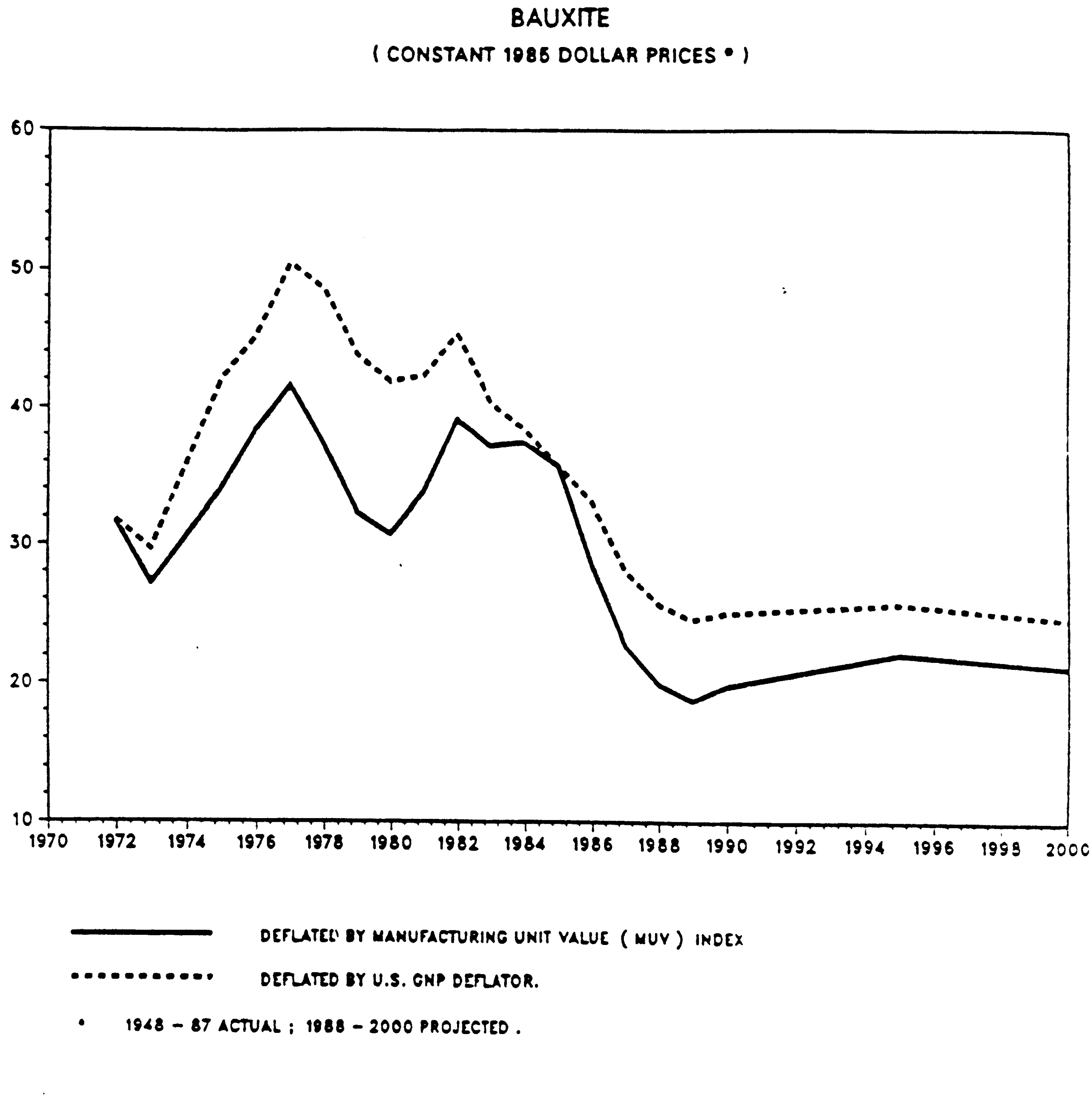
[132] It should be remembered that technology is in the hands of the six Integrated Majors.
[133] The World Bank, Price Prospects for Major Primary Commodities, (Washington D.C., The World Bank, 1989), p. 220.

Figure 26. Bauxite Expected Prices. The World Bank.



SOURCE : WORLD BANK , INTERNATIONAL ECONOMICS DEPARTMENT .

The project systematic risk is defined through its Beta before adjusted for desired leveraged. It is this risk component in the CAPM which represents asset volatility compared to the asset and the market covariance. In the case of an alumina project, the Beta is around 0.95. In the simulations, a Beta of 0.92 was used, the average for the major aluminum companies' Beta.[134] However, this average value is an unleveraged Beta, though at any period the project's Beta was releveraged depending on the debt-equity ratio at the end of each period.[135]

The estimated risk by the Beta component represents the systematic risk of the asset. While the fiscal risk was not explicitly considered in this study, it should nevertheless be evaluated explicitly in the case of international investors. This will affect the probability distribution of expected cash flows. Fiscal risk is defined as "the risk of contractual non-performance by the host government in the form of a unilateral change in stated fiscal terms, if excess profits are earned by the foreign investor because of price or discovery windfalls."[136]

For debt components, a 10% cost of debt is used. This approximates the nominal interest rate of the project loan under consideration by competitive international markets without government guarantees,[137] reflecting the appropriate nominal discount rate for debt contracts. It also reflects the low risk that debt cash flows have due to high interest-coverage ratios, and the customary high debt-equity ratio employed in this type of project. The debt-equity ratio is expected to be around 70% during the initial periods.

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[134] Standard and Poors, Stock Reports NYSE, Jan. 1990-Feb. 1990. See also, Faiz Makdisi-Ilyas, Financial Evaluation of a Bauxite Mining and Alumina Plant Project, Unpublished Thesis, Sloan School of Management, 1980, pp. 35-42.

[135] Leveraged Betas and the Cost of Equity, Harvard Business School Case 9-288-036, 1988.

[136] Panos Cavaulacos, The Impact of Fiscal Risk on Petroleum Investments, Unpublished PhD thesis, Department of Nuclear Engineering, M.I.T., June, 1987.

[137] Venalum C.A. data base.

In reality, the correct evaluation of the present value of the project loans is very complicated, because it must incorporate the contract's option features. In fact, interest payments are usually not contractually fixed, since they are payable at a spread over the chosen base rate on the outstanding principal. The valuation of project loans by option pricing techniques would be rather interesting, however, it is not the concern of this study. For simplicity, it is assumed that CVG has borrowed the total required external financing through a single project-financing entity, the alumina refinery; and that interest payments and principal repayment are payable in assuming an annuity type schedule.

Terminal values of the assets are not considered. Given that the simulation is run for 20 years, terminal present values of the assets will have little impact on the result. Further, if the refinery is built as a state-owned enterprise, it is unlikely to be sold or privatized over its life.

This valuation exercise is intended to serve as a decision-making tool and can be used not only for valuation purposes, but as a tool for risk analysis, as well as for defining contractual efficient arrangements. Table 14 shows the parameters used in the simulation. According to the strategic analysis developed in previous chapters, these are the most sensitive parameters. The simulation results are explained in the following section.

6.2. Results.

The results are not intended to be deterministic. The objective is to show a range of values which will permit the decision maker to define different scenarios and ascertain which variables are the most sensitive. It is important to see how these variables change and how responsive they are in order to allocate risks efficiently among the concerned parties. Appendix A shows the tables in addition to the operating cost, capital costs and base case parameters required to resemble the results. Appendix B contains additional simulation figures on different variables which have relatively low impact on the NPV outcome.

Table 14. Base Case Simulation Parameters.

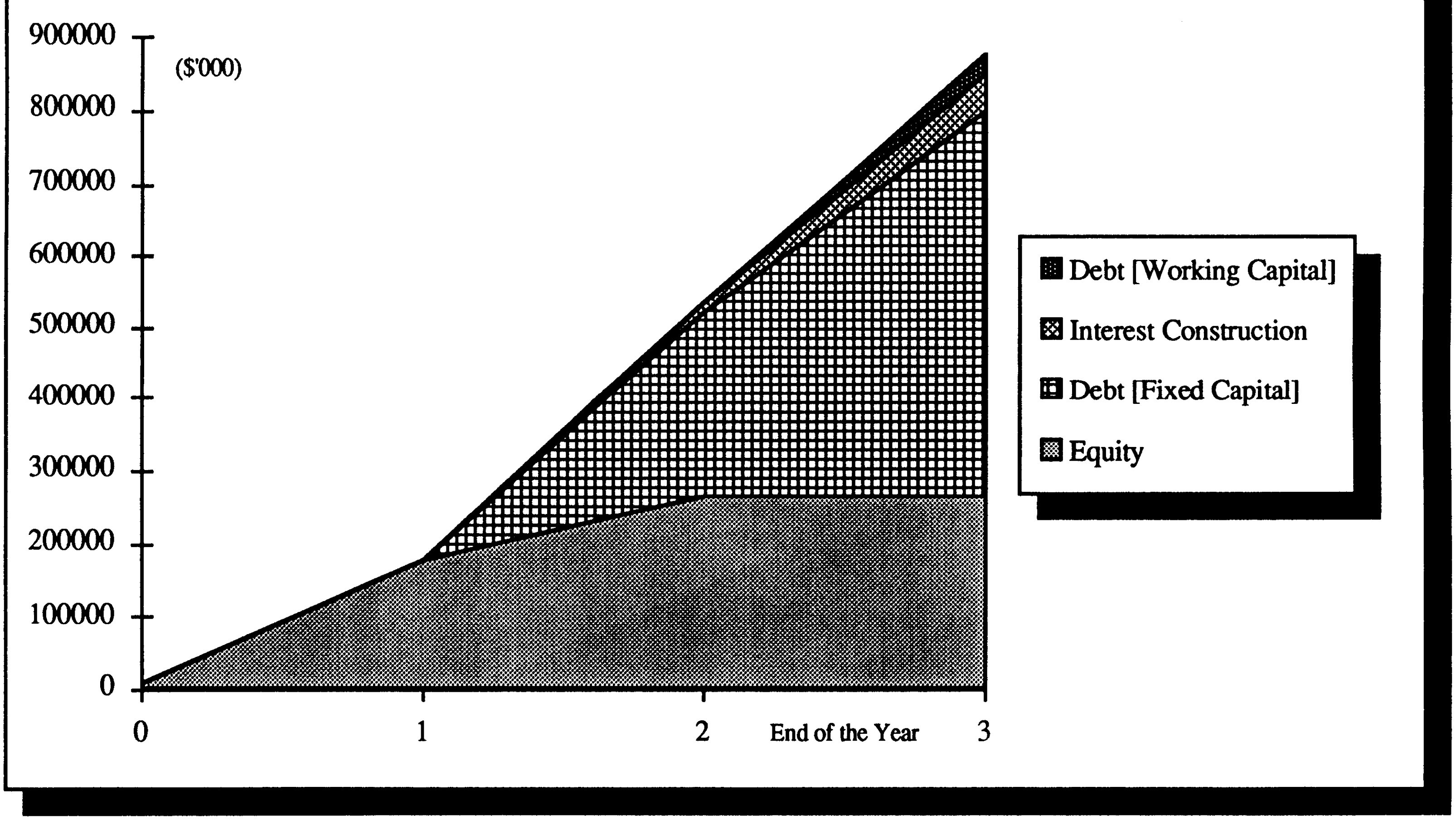
Alumina Price	275 ($/ton)
Alumina Production Schedule	('000 ton,year) (100,3);(650,4);(900,5);(1000,5-22)
Inflation Rate	1.04 (1+%/year)
Investment Costs	800,000 ($'000)
Construction Period	3 (Years, 2<>6)
Percentage Construction Completion per Year	(1,20%);(2,40%);(3,40%) (%,year)
Depreciation Period	20 (Years)
Bauxite Costs	25 ($/ton Bauxite)
Caustic Soda Costs	200 ($/ton Caustic Soda)
Energy Costs	15 ($/ton Alumina)
Labor Costs	15 ($/ton Alumina)
Equity Participation	30 (%)
Debt Participation	70 (%)
Interest Rate on Debt	10 (%)
Debt Repayment Period	15 (Years)
Pre-opening and Organization Costs	8,200 ($'000)
Amortization Period for Preop.&Org.Costs	5 (Years)
Unleveraged Beta for the Project	0.92
Risk Free Rate[138]	0.08
Market Risk Premium[139]	0.086

Figure 27 shows capital outlays during the construction period. The main assumptions are: (1) There is no debt repayment made during this period, (2) interests accrue until the end of the period, (3) working capital needs are determined by two months of operating requirements, and (4) debt-holders' participation does not begin until equity-holders have invested their 100% participation. Note the assumption that there is no difference between interest rates on debt during construction and debt after construction.

138 Interest rate on long term US Government bonds.

139 Roger Ibbotson and Rex Sinquifield, Stocks, Bonds, Bills, and Inflation: Historical Returns (1926-1978),, Charlottesville, VA., Financial Analysis Research Foundation, 1979.

Figure 27. Construction Period Investment Outlays.



Even though higher interest rates are expected during construction, for the sake of simplicity it is better to leave everything at constant rates.

Figures 28 to 30 show the the range of possible cumulative NPV results assuming a base case scenario, a pessimistic scenario, and an optimistic scenario. A constant real alumina price trajectory is assumed, a uniform inflation rate of 4% per year, and a changing nominal discount rate depending on the debt-equity ratio at the end of the period. It is clear, given these assumptions, that the most likely NPV is always close to zero, and that the breakeven outcome is far later in the future, always after Year 20. It is important to note the impact of high initial capital outlays. If the project does not have a steady stream of high cash flows, it will be impossible to make it profitable.

Figure 28 shows the sensitivity to alumina prices. Of all the variables, this is the most volatile. The cumulative NPV outcomes range from approximately plus $200 million to minus $200 million. This wide distribution of outcomes can be explained by high volatility in alumina prices, the imperfections that still exist in the market, and the risks associated with the physical nature of alumina. This is why refineries are forced to engage in contractual agreements to guarantee the allocation and price of their output for which, if risks are well diversified, the expected NPV outcome is zero. The zero NPV outcome for the most likely scenario indicates that, for an average cost producer, there is no incentive to expand capacity.

The price sensitivity to changes in available capacity analyzed in Chapter 5 also explains the wide range in the cumulative NPV. If the refinery chooses to rely on short-term contracts and/or the spot market, its operating cash flows will be highly volatile, as a result of changes in industry capacity. As we saw in Chapter 5, when the market is balanced, alumina prices do reflect market equilibrium. Usually, prices are higher than the market equilibrium due to the premium that alumina buyers are willing to pay to avoid the supply shortage risk. On the other hand, if there is a surplus capacity, alumina prices will reflect the competitive equilibrium.

Figure 28. Sensitivity to Alumina Prices ($/ton).

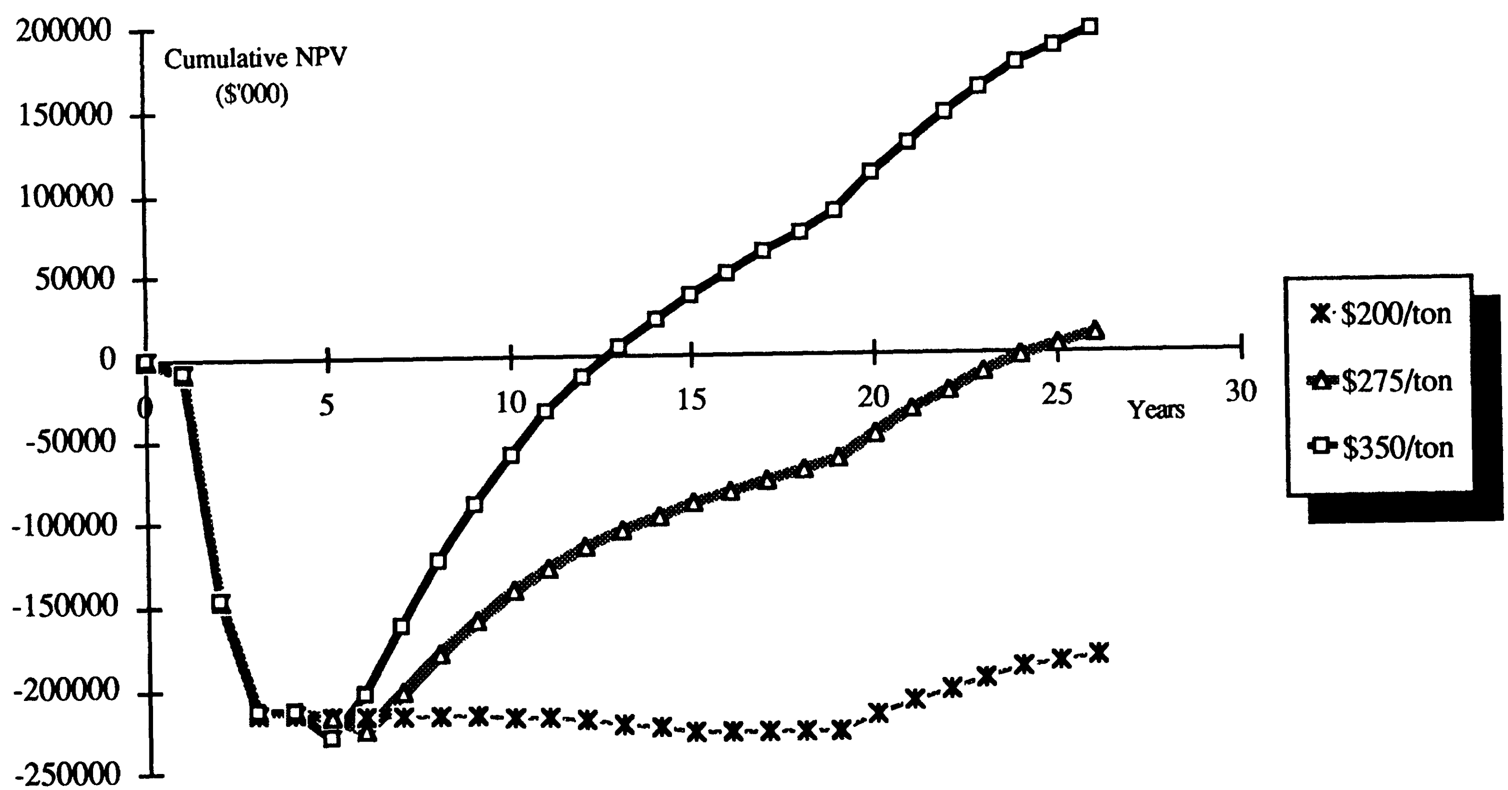
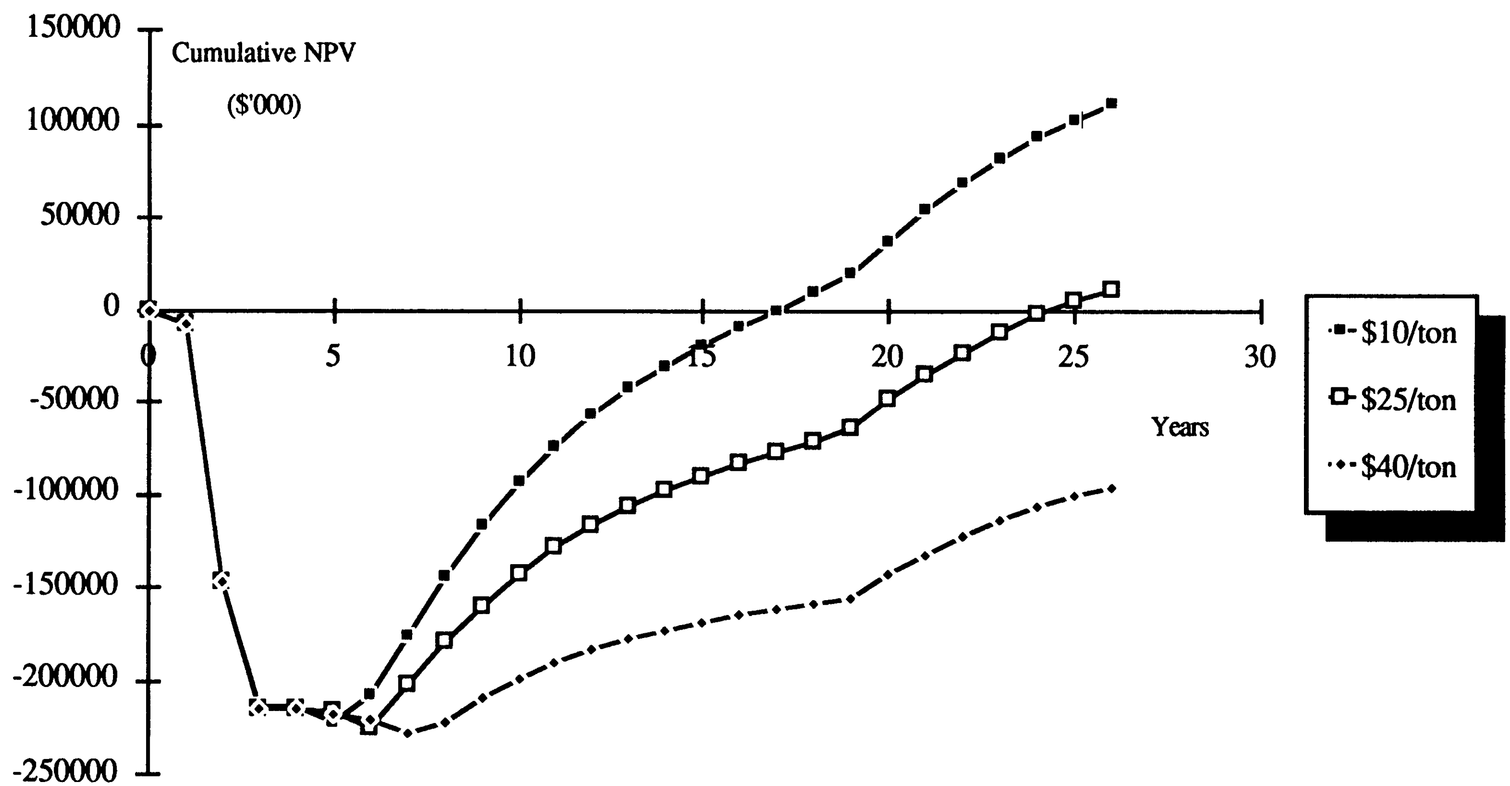


Figure 29. Sensitivity to Bauxite Costs, ($/ton).



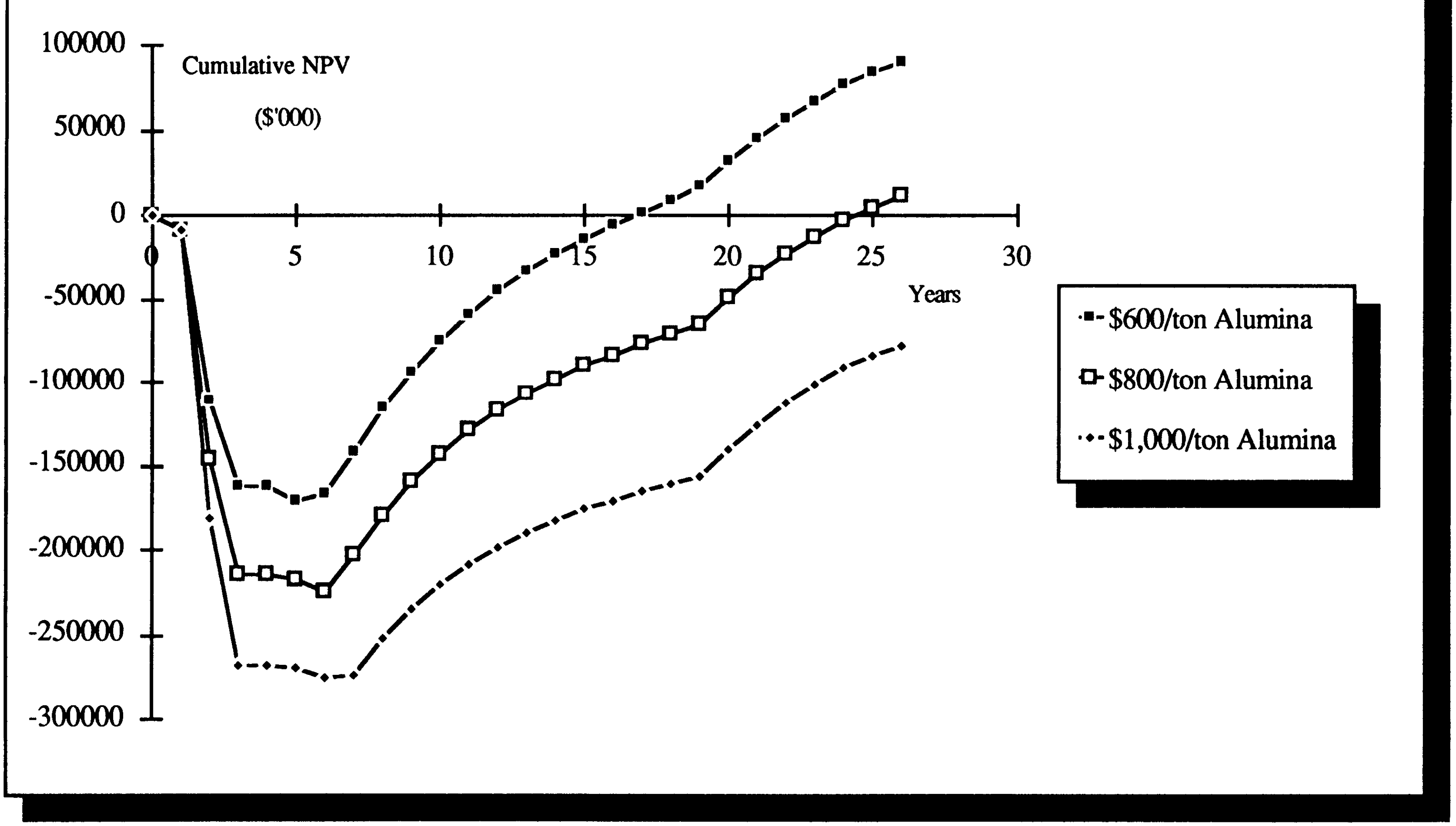


Figure 30. Sensitivity to Investment Costs, ($/ton Alumina).

Figure 29 and 30 show the sensitivity to bauxite and investment costs respectively. These variables are not as sensitive as the alumina price, however, the range between plus $100 million and minus $100 million is important to be considered. Bauxite sensitivity affects the NPV outcome in a way similar to the alumina price. Its sensitivity is largely explained because bauxite represents more than 50% of total operating costs.

In the case of investments costs, impact occurs during the construction period. Although the NPV is not as sensitive to these costs compared to alumina prices or bauxite costs, we consider it the most important variable of the three, because these costs are endogenous, can be controlled internally to some extent by the firm, and because once investment costs are committed, the final outcome is almost defined. If the cost of the refinery is above $800 per ton, it will be almost impossible to make the project profitable.

Figures 31 and 32 show the sensitivity to the construction period. If percentage completion is distributed proportionally over the construction period, there is a major difference in the resultant cumulative NPV. These figures represent the NPV as a function of different investment costs for any given bauxite and alumina price. Because non-linearities are not included in the simulation, all relations are linear. The following equations define the set of schedules plotted in Figures 31 and 32:

For 3-year construction period [Figure 31]:

NPV(3-yrs)=-0.40*Cap.Inv+[2.47*Alumina-6.67*Bauxite-0.16*CausticSoda-2.85*Energy-131.56]

For 5-year construction period [Figure 32]:

NPV(5-yrs.)=-27Cap.Inv+[1.66*Alumina-4.43*Bauxite-139.58]

As the construction period increases the capital investment coefficient and the intercept decrease, if some delay occurs during construction it will be harder to turn the project profitable. As the capital investment coefficient decreases, the project's upside potential decreases considerably. Even though the slope changes, the spread between curves in both sets is almost the same, showing that sensitivity to bauxite costs is exogenous to the project.

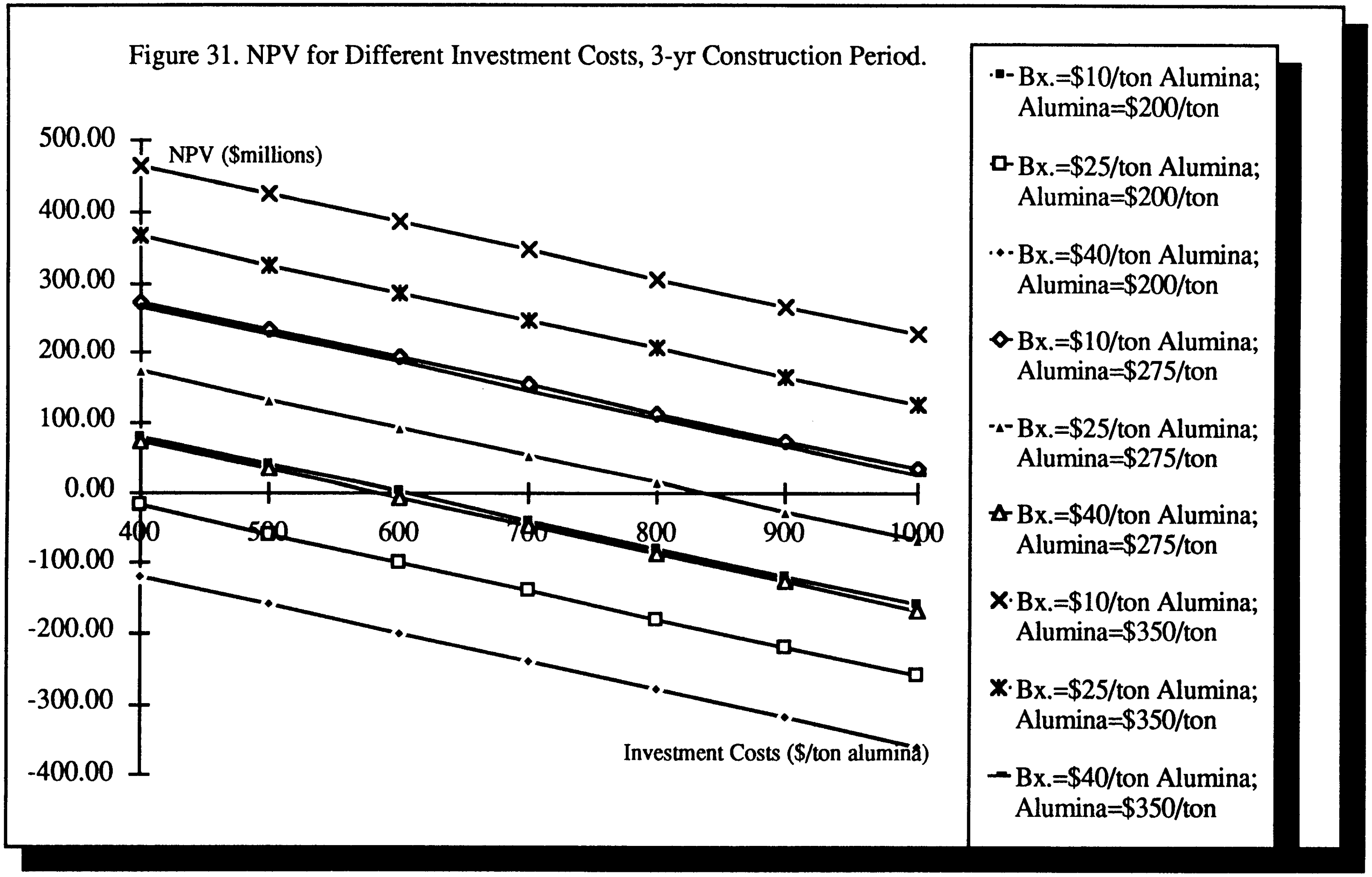
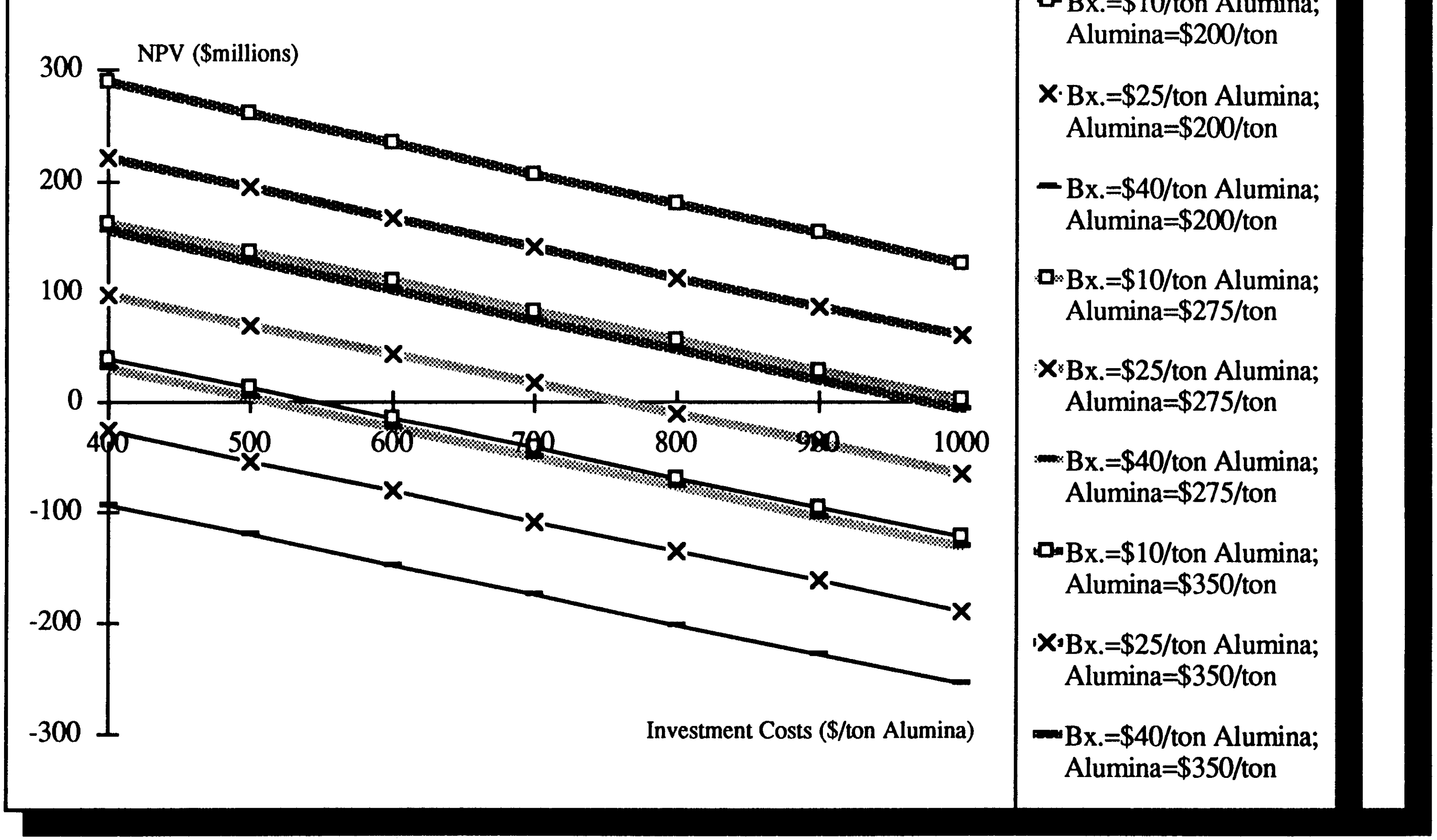


Figure 31. NPV for Different Investment Costs, 3-yr Construction Period.

Figure 32. NPV for Different Investment Costs. Construction Period 5-yrs.



Figures 33 and 34 show how insensitive the project is to changes in energy and caustic soda prices. Although in the cost structure analysis energy exhibited a high variability in energy costs among firms and regions, the NPV outcome is not that sensitive to this variable. This explains the fact that refineries in India having extremely high energy costs are operating. On the other hand, CVG's refinery, with one of the lowest energy costs in the industry, has average operating costs due to high bauxite costs.

The results of the NPV sensitivity analysis to alumina prices, and investment, bauxite, energy and caustic soda costs indicate that, in all cases, the base case scenario has a zero NPV outcome and the breakeven point is far in the future. Competitive advantage in alumina investments stems primarily from low bauxite costs and low investment costs. It is important to note the irrelevance of changes in energy and caustic soda costs. CVG-Al's main concern should be its high bauxite costs, thus shifting the company's focus to its bauxite operations as the first priority.

Figure 33. NPV for Different Energy Costs.

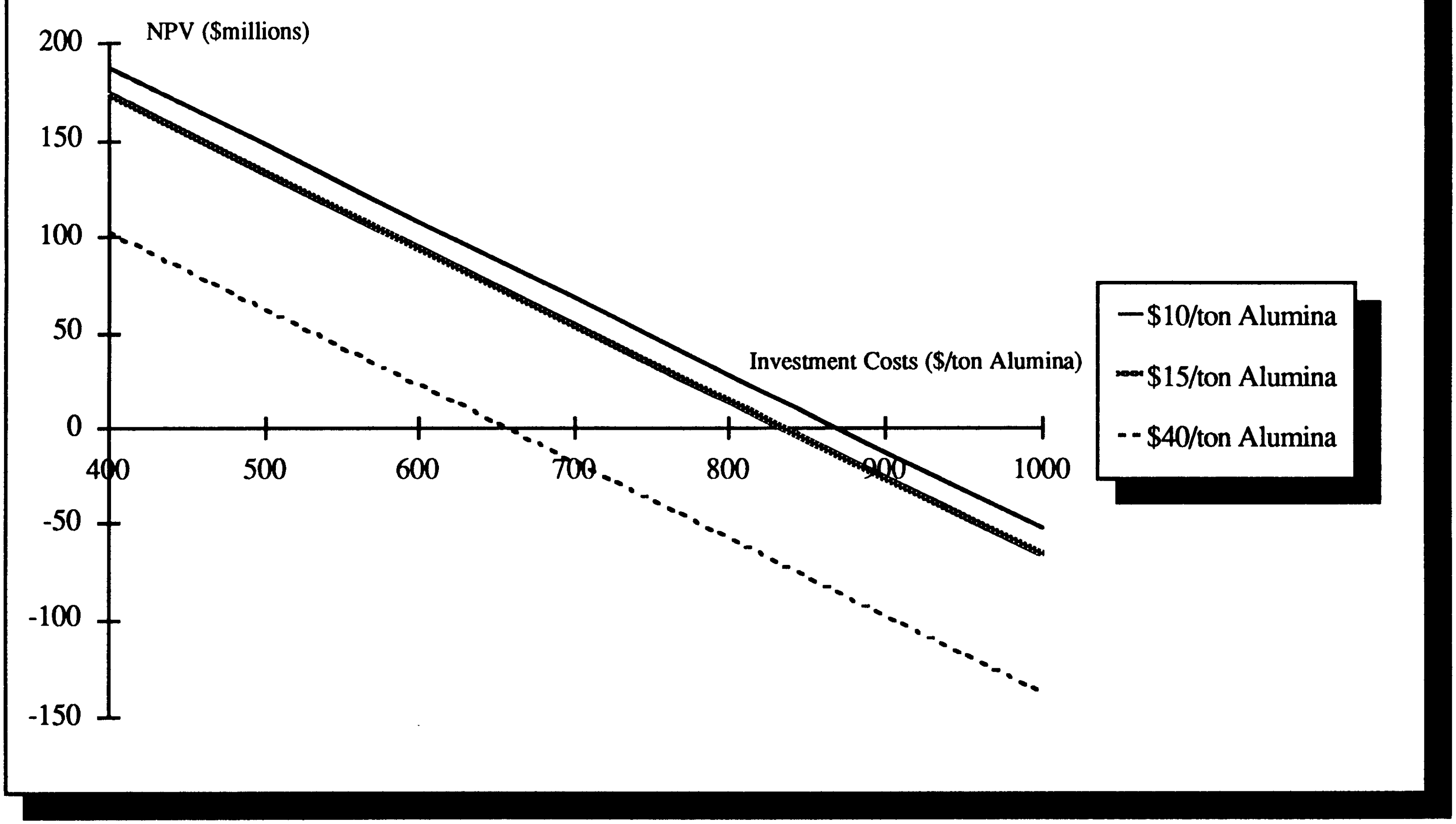
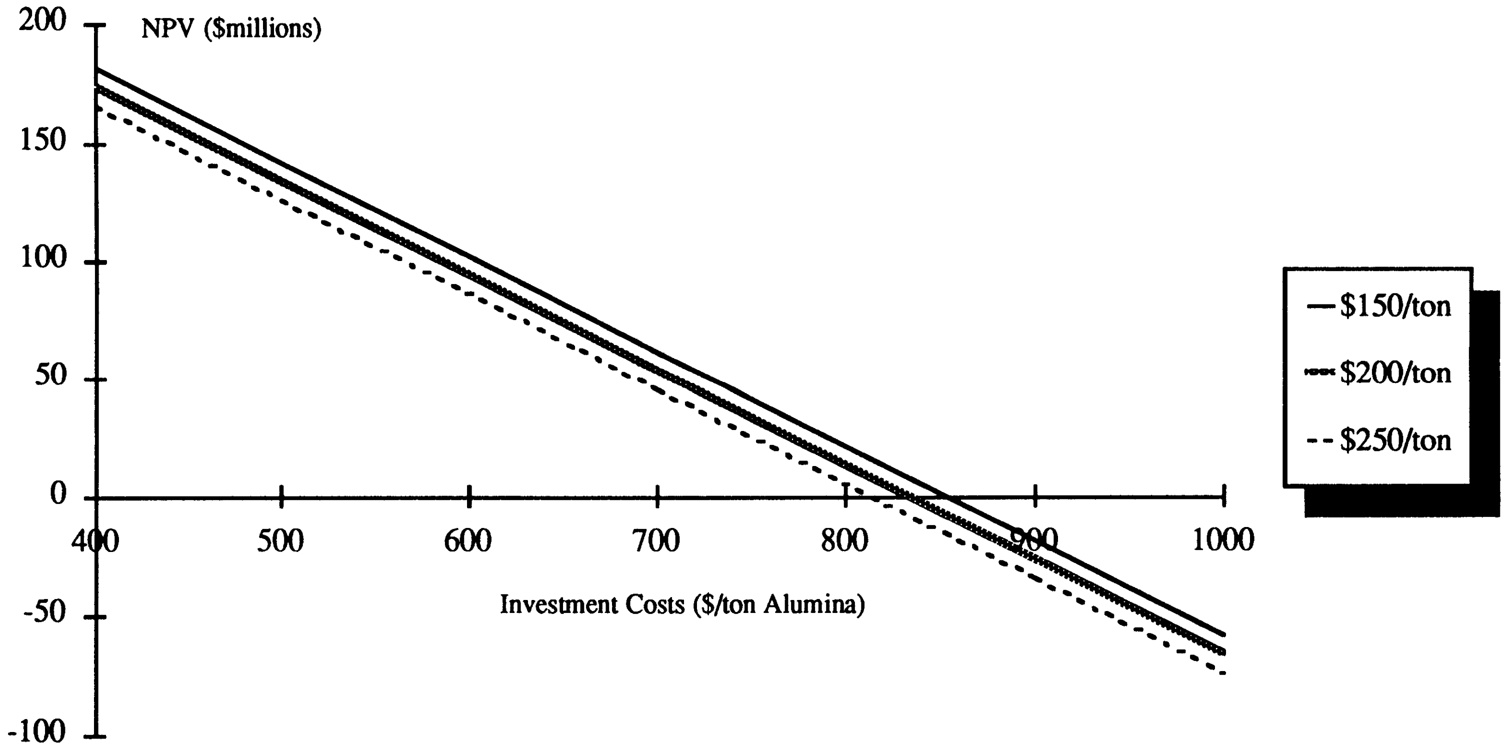


Figure 34. NPV for Different Caustic Soda Prices. Alumina Price $275/ton. Construction Period 3-yrs.



Chapter 7
Conclusion and Recommendations

An increase in alumina capacity above its current capacity of two million tons per year is not recommended. If increases in alumina capacity are targeting the primary aluminum expansion program in Venezuela,[140] and CVG-Aluminum will only have approximately 20% equity participation, what is the interest in promoting a zero-NPV alumina project? Since CVG-Aluminum, through its subsidiary Interalumina C.A., is currently long in alumina[141], and given expectations of a higher NPV for primary aluminum investments, where should CVG-Aluminum focus its capital investment resources?

Currently, CVG is in an inefficient position. Its alumina sector is long when the market is expected to decline, primary expansions have been delayed, and the bauxite mine has not yet began to produce efficiently. Given this transitory situation, the aluminum sector should be restructured with emphasis in cost optimization policies, to respond to an integrated strategy taking into account Venezuela's comparative advantages in aluminum and the current economic situation.

Venezuela has clear competitive advantages in producing primary aluminum. These advantages stem from low-cost sources of energy, a long alumina position, and an anticipated decrease in bauxite costs. The combination of these advantages and an expected stable primary aluminum market[142] permit CVG-AL to take a more aggressive position in primary aluminum, and to bear some of the risks associated with the industry, such as alumina price volatility, and concentration levels on downstream markets. By increasing

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140 The objective is to reach two million tons per year of installed capacity by the year 2000.

141 Current primary production is about 600k tons per year, requiring approximately 1,200k tons of alumina per year.

142 Shearson-Lehman-Hutton, Annual Review of the World Aluminum Industry, (1989), pp. 41-48.

primary aluminum capacity, the option to expand downstream by merging and/or joint ventures provides CVG-AL with flexibility in designing an optimal investment plan. In considering any upstream capacity expansion, CVG-AL should first exhaust all alternatives provided by external markets for structuring a balanced portfolio of contracts and securities to optimize its desired risk-return position.

The integration of alumina and bauxite operations does not depend on the assumption of a particular market structure; but, rather, on certain technical and economic arguments, such as the non-homogeneity of bauxite, the scale of production, and the importance of freight costs. The integration of alumina and primary aluminum operations however, does depend on the existence of a particular industry organization. This is an important distinction, in that if vertical integration depends on technical and economic factors, a vertical structure is recommended. The recommendation will not change unless there is some change in technology, such as in production processes or minimum efficient scale. But, if vertical integration depends on the organization of the industry, then optimal organization can change from being vertically integrated to a more competitive environment, as conditions change.

There has been a long and slow process of disintegration at the industry level as the share of integrated producers has gradually declined. The segmentation and growth of the alumina and primary aluminum markets have reduced the risk of not being integrated across these markets, thus reducing the need for being vertically integrated. With the growth, particularly of Independent Smelters and Miner/Refiners, the rules of the game have changed to that of a quasi-competitive organization.

As a result of this disintegration process, the overall importance of the Integrated Majors will continue to be reduced by the growth of the Independent Smelters group. In addition, intensified rivalry among members of the Integrated group will occur as they all seek to exploit down-stream markets, and as the industry globalization trend continues to occur. The long process of declining integration at the industry level is expected to continue, and will be influenced by the economic cycle where disintegration is going to be accelerated by economic troughs and retarded by strong economic conditions.

The alumina industry has an oligopolistic underlying structure which, if primary prices are low, the optimal price is close or equal to its competitive equilibrium. If primary aluminum prices are high, however, the dominant firm, Alcoa of Australia, sets an optimum price, which is much higher than the perfect competitive price. Prices not only depend on supply and demand balance, but on different factors and contractual agreements such as the length of the contract, escalation formulas, freight costs, aluminum prices, negotiation power of the parties concerned, and the ability of the producers to collude. This situation arises because supply and demand curves are characterized by being almost perfectly elastic at low cost ends. But, for the marginal firm, these curves change to an inelastic condition. Therefore, at the margin the market is highly sensitive to changes in alumina capacity.

As a result of high sensitivity to capacity changes, the alumina market experienced a high volatility in prices. This is why it is in the interest of Second-Tier producers to serve as catalysts in new alumina projects when the market is close to balanced. By investing in capacity expansions, Second-Tier producers will guarantee low alumina prices and more importantly, stable contracts for their alumina requirements. On the other hand, firms with long alumina position, such as CVG, would be interested in maintaining a tight alumina market.

Finally, from Venezuela's perspective, non-positive NPV projects should not be undertaken, even if they are supported on the grounds of being catalysts for economic development. To foster sustainable, long-term growth, Venezuela should pursue strong projects which do not require subsidies or preferential financing arrangements to make them profitable.

Appendix A

This appendix contains additional tables required to obtain the base case results. The following tables are included:

Tables 15a-15c. Income Statement.

Tables 16a-16c. Balance Sheet.

Tables 17a-17c. Loan Schedule.

Tables 18a-18c. Free-Cash Flows to Equity.

Table 15a. Income Statement ($'000)

	0	1	2	3	4	5	6	7	8	9
Year End	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Inflation Rate	1.00	1.04	1.08	1.12	1.17	1.22	1.27	1.32	1.37	1.42
Net Sales	0	0	0	30,934	209,112	301,122	347,963	361,881	376,356	391,411
Cost of Goods Sold	0	0	0	12,987	87,792	126,420	146,086	151,929	158,006	164,326
Gross Profit	0	0	0	17,947	121,320	174,701	201,877	209,952	218,350	227,084
Selling, General and Administrative	0	0	0	1,547	10,456	15,056	17,398	18,094	18,818	19,571
Depreciation	0	0	0	0	40,000	40,000	40,000	40,000	40,000	40,000
Amortization Preop. Exp. & Org. Cos	0	0	0	0	1,640	1,640	1,640	1,640	1,640	0
Total Operating Expenses	0	0	0	1,547	52,096	56,696	59,038	59,734	60,458	59,571
Net Operating Incom	0	0	0	16,400	69,225	118,005	142,839	150,218	157,893	167,514
Interest Expense @ 36%	0	0	24,718	62,006	64,786	60,055	57,908	55,547	52,949	50,092
Earnings before Taxes	0	0	(24,718)	(45,606)	4,438	57,951	84,931	94,672	104,944	117,422
Income Taxes	0	0	0	0	1,598	20,862	30,575	34,082	37,780	42,272
Net Income	0	0	(24,718)	(45,606)	2,841	37,088	54,356	60,590	67,164	75,150
Dividends	0	0	0	0	2,556	33,380	48,920	54,531	60,447	67,635

Table 15b. Income Statement ($'000) (cont.)

	10	11	12	13	14	15	16	17	18	19
Year End	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Inflation Rate	1.48	1.54	1.60	1.67	1.73	1.80	1.87	1.95	2.03	2.11
Net Sales	407,067	423,350	440,284	457,895	476,211	495,259	515,070	535,673	557,100	579,384
Cost of Goods Sold	170,899	177,735	184,845	192,239	199,928	207,925	216,242	224,892	233,888	243,243
Gross Profit	236,168	245,615	255,439	265,657	276,283	287,334	298,828	310,781	323,212	336,140
Selling, General and Administrative	20,353	21,167	22,014	22,895	23,811	24,763	25,753	26,784	27,855	28,969
Depreciation	40,000	40,000	40,000	40,000	40,000	40,000	40,000	40,000	40,000	40,000
Amortization Preop. Exp. & Org. Cos	0	0	0	0	0	0	0	0	0	0
Total Operating Expenses	60,353	61,167	62,014	62,895	63,811	64,763	65,753	66,784	67,855	68,969
Net Operating Incom	175,814	184,447	193,425	202,762	212,472	222,571	233,074	243,997	255,357	267,171
Interest Expense @ 36%	46,949	43,491	39,688	35,505	30,903	25,841	20,273	14,148	7,411	0
Earnings before Taxes	128,866	140,956	153,737	167,257	181,569	196,730	212,801	229,849	247,946	267,171
Income Taxes	46,392	50,744	55,345	60,212	65,365	70,823	76,608	82,746	89,261	96,182
Net Income	82,474	90,212	98,391	107,044	116,204	125,907	136,193	147,103	158,685	170,990
Dividends	74,227	81,190	88,552	96,340	104,584	113,316	122,573	132,393	142,817	153,891

Table 15c. Income Statement ($'000) (cont.)

	20	21	22	23	24	25
Year End	2010	2011	2012	2013	2014	2015
Inflation Rate	2.19	2.28	2.37	2.46	2.56	2.67
Net Sales	602,559	626,661	651,728	677,797	704,909	733,105
Cost of Goods Sold	252,973	263,092	273,615	284,560	295,942	307,780
Gross Profit	349,586	363,569	378,112	393,237	408,966	425,325
Selling, General and Administrative	30,128	31,333	32,586	33,890	35,245	36,655
Depreciation	40,000	40,000	40,000	40,000	0	0
Amortization Preop. Exp. & Org. Cos	0	0	0	0	0	0
Total Operating Expenses	70,128	71,333	72,586	73,890	35,245	36,655
Net Operating Incom	279,458	292,236	305,526	319,347	373,721	388,670
Interest Expense @ 36%	0	0	0	0	0	0
Earnings before Taxes	279,458	292,236	305,526	319,347	373,721	388,670
Income Taxes	100,605	105,205	109,989	114,965	134,539	139,921
Net Income	178,853	187,031	195,537	204,382	239,181	248,749
Dividends	160,968	168,328	175,983	183,944	215,263	223,874

Table 16a. Balance Sheet ($'000)

Year End	0 1990	1 1991	2 1992	3 1993	4 1994	5 1995	6 1996	7 1997	8 1998
Inflation Rate	1.00	1.04	1.08	1.12	1.17	1.22	1.27	1.32	1.37
Assets									
Current Assets									
Cash and Marketable Securities	0	0	0	0	10,450	10,920	11,412	11,925	12,462
Accounts Receivables	0	0	0	2,543	17,187	24,750	28,600	29,744	30,933
Inventories	0	0	0	4,640	31,367	45,168	52,194	54,282	56,453
Prepaid Expenses	0	0	0	309	2,091	3,011	3,480	3,619	3,764
Total Current Assets	0	0	0	7,492	61,095	83,849	95,685	99,570	103,612
Property, Plant and Equipment, net	0	160,000	480,000	800,000	760,000	720,000	680,000	640,000	600,000
Preopening Expenses & Org. Costs	8,200	8,200	8,200	8,200	6,560	4,920	3,280	1,640	0
Other Assets	0	0	0	1,856	12,547	18,067	20,878	21,713	22,581
Total Fixed Assets	8,200	168,200	488,200	810,056	779,107	742,987	704,158	663,353	622,581
Total Assets	8,200	168,200	488,200	817,548	840,202	826,837	799,843	762,923	726,194
Liabilities and Net Worth									
Current Liabilities									
Short Term Debt	0	0	0	0	27,802	0	0	0	0
Account Payable	0	0	0	1,449	9,412	11,525	12,585	12,659	13,165
Total Current Liabilities	0	0	0	1,449	37,214	11,525	12,585	12,659	13,165
Portion to Social Security Benefits	0	0	0	619	4,182	6,022	6,959	7,238	7,527
Long Term Debt	0	0	247,176	620,063	600,547	579,080	555,466	529,491	500,918
Total Fixed Liabilities	0	0	247,176	620,682	604,730	585,102	562,425	536,728	508,445
Total Liabilities	0	0	247,176	622,130	641,944	596,627	575,010	549,387	521,610
Net Worth	8,200	168,200	512,918	885,804	866,289	839,684	756,338		
Common Stock	8,200	168,200	265,741	265,741	265,741	265,741	265,741	265,741	265,741
Retained Earnings	0	0	(24,718)	(70,324)	(67,483)	(30,395)	23,961	84,551	151,715
Total Net Worth	8,200	168,200	241,024	195,417	198,258	230,209	224,833	213,536	204,584
Total Liabilities & Net Worth	8,200	168,200	488,200	817,548	840,202	831,974	864,712	899,679	939,066
Dividends	0	0	0	0	0	5,137	64,869	136,756	212,872
tal Liabilities & Net Worth. After Div.	8,200	168,200	488,200	817,548	840,202	826,837	799,843	762,923	726,194

Table 16b. Balance Sheet ($'000) (cont.)

	9	11	12	13	14	15	16	17	18
Year End	1999	2001	2002	2003	2004	2005	2006	2007	2008
Inflation Rate	1.42	1.54	1.60	1.67	1.73	1.80	1.87	1.95	2.03
Assets									
Current Assets									
Cash and Marketable Securities	13,023	14,221	14,861	15,530	16,229	16,959	17,722	18,519	19,353
Accounts Receivables	32,171	34,796	36,188	37,635	39,141	40,706	42,335	44,028	45,789
Inventories	58,712	63,502	66,043	68,684	71,432	74,289	77,260	80,351	83,565
Prepaid Expenses	3,914	4,233	4,403	4,579	4,762	4,953	5,151	5,357	5,571
Total Current Assets	107,819	116,753	121,494	126,428	131,563	136,907	142,468	148,255	154,278
Property, Plant and Equipment, net	560,000	480,000	440,000	400,000	360,000	320,000	280,000	240,000	200,000
Preopening Expenses & Org. Costs	0	0	0	0	0	0	0	0	0
Other Assets	23,485	25,401	26,417	27,474	28,573	29,716	30,904	32,140	33,426
Total Fixed Assets	583,485	505,401	466,417	427,474	388,573	349,716	310,904	272,140	233,426
Total Assets	691,304	622,154	587,911	553,902	520,136	486,622	453,372	420,395	387,704
Liabilities and Net Worth									
Current Liabilities									
Short Term Debt	0	0	0	0	0	0	0	0	0
Account Payable	13,692	14,809	15,401	16,018	16,658	17,325	18,018	18,738	19,488
Total Current Liabilities	13,692	14,809	15,401	16,018	16,658	17,325	18,018	18,738	19,488
Portion to Social Security Benefits	7,828	8,467	8,806	9,158	9,524	9,905	10,301	10,713	11,142
Long Term Debt	469,487	396,883	355,050	309,033	258,414	202,733	141,485	74,111	0
Total Fixed Liabilities	477,315	405,350	363,855	318,191	267,938	212,638	151,786	84,824	11,142
Total Liabilities	491,007	420,159	379,257	334,208	284,596	229,963	169,803	103,563	30,630
Net Worth									
Common Stock	265,741	265,741	265,741	265,741	265,741	265,741	265,741	265,741	265,741
Retained Earnings	226,865	399,551	497,942	604,986	721,191	847,098	983,290	1,130,393	1,289,079
Total Net Worth	200,296	201,994	208,654	219,694	235,539	256,659	283,568	316,833	357,074
Total Liabilities & Net Worth	983,614	1,085,451	1,142,940	1,204,936	1,271,528	1,342,802	1,418,835	1,499,697	1,585,450
Dividends	292,310	463,297	555,029	651,034	751,393	856,180	965,463	1,079,302	1,197,746
tal Liabilities & Net Worth. After Div.	691,304	622,154	587,911	553,902	520,136	486,622	453,372	420,395	387,704

Table 16c. Balance Sheet ($'000) (cont.)

	19	20	21	22	23	24	25
Year End	2009	2010	2011	2012	2013	2014	2015
Inflation Rate	2.11	2.19	2.28	2.37	2.46	2.56	2.67
Assets							
Current Assets							
Cash and Marketable Securities	20,224	21,134	22,085	23,079	24,117	25,202	26,337
Accounts Receivables	47,621	49,525	51,506	53,567	55,709	57,938	60,255
Inventories	86,908	90,384	93,999	97,759	101,670	105,736	109,966
Prepaid Expenses	5,794	6,026	6,267	6,517	6,778	7,049	7,331
Total Current Assets	160,546	167,069	173,857	180,922	188,274	195,925	203,889
Property, Plant and Equipment, net	160,000	120,000	80,000	40,000	0	0	0
Preopening Expenses & Org. Costs	0	0	0	0	0	0	0
Other Assets	34,763	36,154	37,600	39,104	40,668	42,295	43,986
Total Fixed Assets	194,763	156,154	117,600	79,104	40,668	42,295	43,986
Total Assets	355,309	323,222	291,457	260,025	228,942	238,220	247,875
Liabilities and Net Worth							
Current Liabilities							
Short Term Debt	0	0	0	0	0	0	0
Account Payable	20,267	21,078	21,921	22,798	23,710	24,658	25,645
Total Current Liabilities	20,267	21,078	21,921	22,798	23,710	24,658	25,645
Portion to Social Security Benefits	11,588	12,051	12,533	13,035	13,556	14,098	14,662
Long Term Debt	0	0	0	0	0	0	0
Total Fixed Liabilities	11,588	12,051	12,533	13,035	13,556	14,098	14,662
Total Liabilities	31,855	33,129	34,454	35,833	37,266	38,756	40,307
Net Worth							
Common Stock	265,741	265,741	265,741	265,741	265,741	265,741	265,741
Retained Earnings	1,460,068	1,638,921	1,825,953	2,021,489	2,225,871	2,465,053	2,713,801
Total Net Worth	323,454	290,093	257,002	224,193	191,676	199,464	207,568
Total Liabilities & Net Worth	1,757,665	1,937,792	2,126,148	2,323,063	2,528,878	2,769,550	3,019,849
Dividends	1,402,356	1,614,570	1,834,692	2,063,038	2,299,937	2,531,330	2,771,974
tal Liabilities & Net Worth. After Div.	355,309	323,222	291,457	260,025	228,942	238,220	247,875

Table 17a. Loan Schedule @ 10%, 15yrs ($'000)

	0	1	2	3	4	5	6	7	8	9
Year End	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Inflation Rate	1.00	1.04	1.08	1.12	1.17	1.22	1.27	1.32	1.37	1.42
Debt Financing										
Debt Balance	0	0	0	620,063	620,063	600,547	579,080	555,466	529,491	500,918
Debt Repayment	0	0	0	0	81,522	81,522	81,522	81,522	81,522	81,522
Interest	0	0	0	0	62,006	60,055	57,908	55,547	52,949	50,092
AMT	0	0	0	0	19,516	21,467	23,614	25,975	28,573	31,430
Balance end Year	0	0	0	620,063	600,547	579,080	555,466	529,491	500,918	469,487
Total Interest	0	0	0	0	62,006	60,055	57,908	55,547	52,949	50,092
Total Amortization	0	0	0	0	19,516	21,467	23,614	25,975	28,573	31,430

Table 17b. Loan Schedule @ 10%, 15yrs ($'000) (cont.).

	10	11	12	13	14	15	16	17	18	19
Year End	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Inflation Rate	1.48	1.54	1.60	1.67	1.73	1.80	1.87	1.95	2.03	2.11
Debt Financing										
Debt Balance	469,487	434,914	396,883	355,050	309,033	258,414	202,733	141,485	74,111	0
Debt Repayment	81,522	81,522	81,522	81,522	81,522	81,522	81,522	81,522	81,522	0
Interest	46,949	43,491	39,688	35,505	30,903	25,841	20,273	14,148	7,411	0
AMT	34,573	38,031	41,834	46,017	50,619	55,681	61,249	67,374	74,111	0
Balance end Year	434,914	396,883	355,050	309,033	258,414	202,733	141,485	74,111	0	0
Total Interest	46,949	43,491	39,688	35,505	30,903	25,841	20,273	14,148	7,411	0
Total Amortization	34,573	38,031	41,834	46,017	50,619	55,681	61,249	67,374	74,111	0

Table 17c. Loan Schedule @ 10%, 15yrs ($'000) (cont.).

	20	21	22	23	24	25
Year End	2010	2011	2012	2013	2014	2015
Inflation Rate	2.19	2.28	2.37	2.46	2.56	2.67
Debt Financing						
Debt Balance	0	0	0	0	0	0
Debt Repayment	0	0	0	0	0	0
Interest	0	0	0	0	0	0
AMT	0	0	0	0	0	0
Balance end Year	0	0	0	0	0	0
Total Interest	0	0	0	0	0	0
Total Amortization	0	0	0	0	0	0

Table 18a. Free Cash Flow to Equity ($'000).

	0	1	2	3	4	5	6	7	8	9
Year End	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Inflation Rate	1.00	1.04	1.08	1.12	1.17	1.22	1.27	1.32	1.37	1.42
Net Income	0	0	(24,718)	(45,606)	284	3,709	5,436	6,059	6,716	7,515
Dividends						5,137	59,732	71,888	76,116	79,438
Change in Working Capital	0	0	0	(7,492)	(53,603)	(22,754)	(11,836)	(3,884)	(4,042)	(4,207)
Capital Expenditures	(8,214)	(160,000)	(320,000)	(320,000)	0	0	0	0	0	0
Depreciation	0	0	0	0	40,000	40,000	40,000	40,000	40,000	40,000
Extras:										
Amt. Preop. & Org. Cos	0	0	0	0	0	1,640	1,640	1,640	1,640	1,640
Debt Repayment	0	0	247,176	372,887	8,286	(49,269)	(23,614)	(25,975)	(28,573)	(31,430)
FCFe	(8,214)	(160,000)	(97,541)	(211)	(5,033)	(21,537)	71,357	89,727	91,857	92,955
Discounted FCFe	(8,214)	(138,036)	(68,049)	(118)	(2,312)	(8,190)	22,442	23,383	19,883	16,763

Table 18b. Free Cash Flow to equity ($'000).

	10	11	12	13	14	15	16	17	18	19
Year End	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Inflation Rate	1.48	1.54	1.60	1.67	1.73	1.80	1.87	1.95	2.03	2.11
Net Income	8,247	9,021	9,839	10,704	11,620	12,591	13,619	14,710	15,869	17,099
Dividends	83,444	87,543	91,731	96,005	100,359	104,787	109,283	113,839	118,444	204,610
Change in Working Capital	(4,378)	(4,556)	(4,741)	(4,934)	(5,135)	(5,344)	(5,561)	(5,787)	(6,023)	(6,268)
Capital Expenditures	0	0	0	0	0	0	0	0	0	0
Depreciation	40,000	40,000	40,000	40,000	40,000	40,000	40,000	40,000	40,000	40,000
Extras:										
Amt. Preop. & Org. Cos	0	0	0	0	0	0	0	0	0	0
Debt Repayment	(34,573)	(38,031)	(41,834)	(46,017)	(50,619)	(55,681)	(61,249)	(67,374)	(74,111)	0
FCFe	92,741	93,978	94,996	95,758	96,226	96,354	96,093	95,388	94,179	255,441
Discounted FCFe	13,988	11,918	10,200	8,791	7,660	6,797	6,220	6,029	6,601	15,447

Table 18c. Free Cash Flow to equity ($'000).

	20	21	22	23	24	25
Year End	2010	2011	2012	2013	2014	2015
Inflation Rate	2.19	2.28	2.37	2.46	2.56	2.67
Net Income	17,885	18,703	19,554	20,438	23,918	24,875
Dividends	212,214	220,122	228,346	236,899	231,394	240,644
Change in Working Capital	(6,523)	(6,788)	(7,065)	(7,352)	(7,652)	(7,963)
Capital Expenditures	0	0	0	0	0	0
Depreciation	40,000	40,000	40,000	40,000	0	0
Extras:						
Amt. Preop. & Org. Cos	0	0	0	0	0	0
Debt Repayment	0	0	0	0	0	0
FCFe	263,576	272,037	280,835	289,985	247,660	257,556
Discounted FCFe	13,751	12,244	10,905	9,715	7,158	6,422

Appendix B

This appendix contains additional sensitivity analysis. The following figures are included:

Figure 35. Sensitivity to Equity Participation.

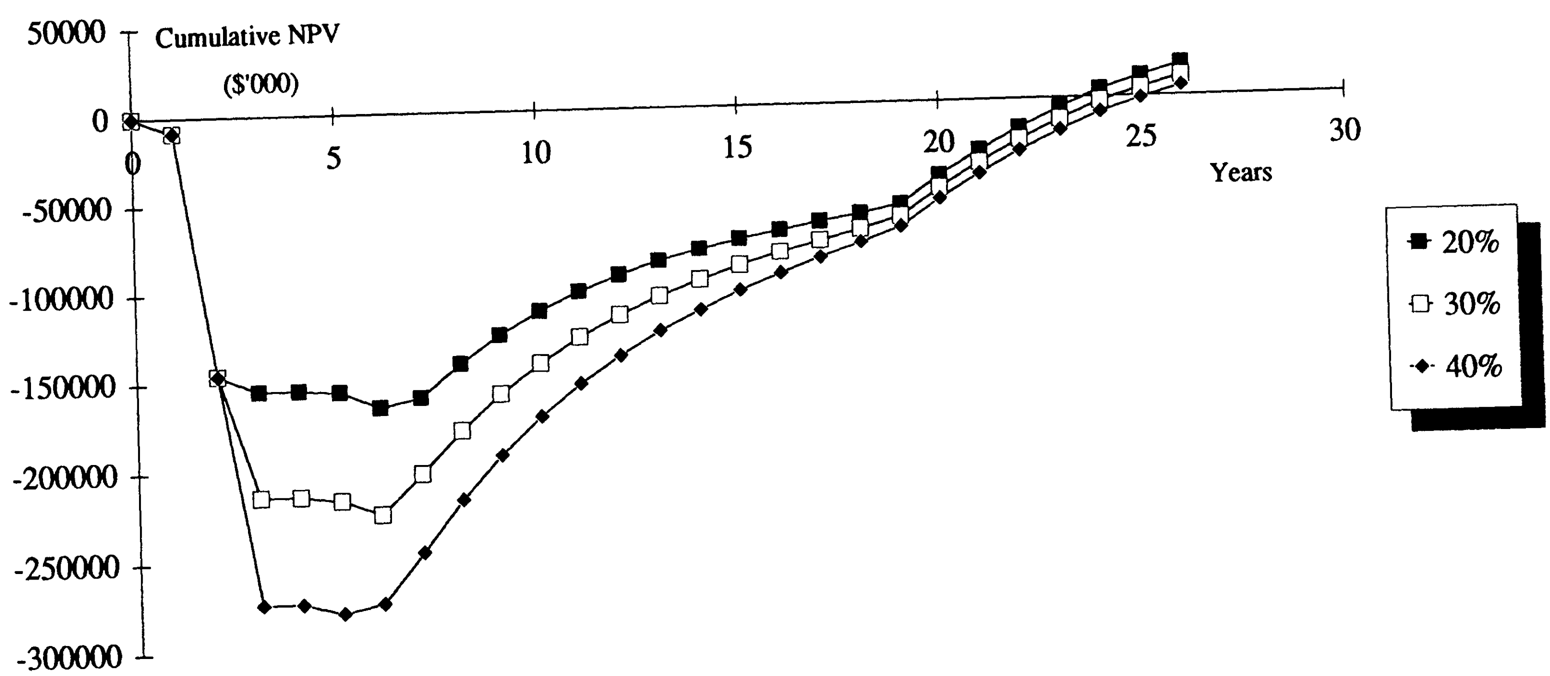


Figure 36. Sensitivity to Construction Period.

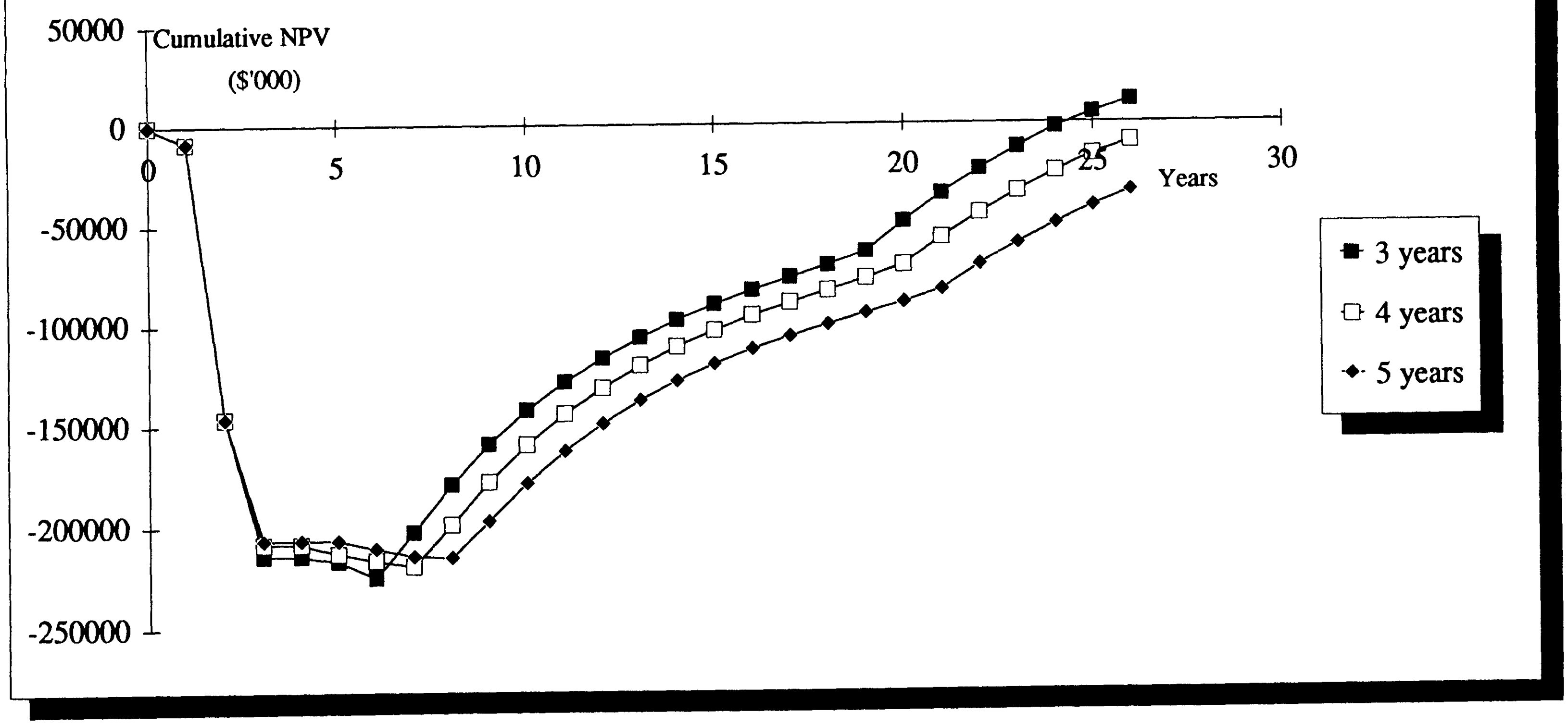


Figure 37. Sensitivity to Time Delays.

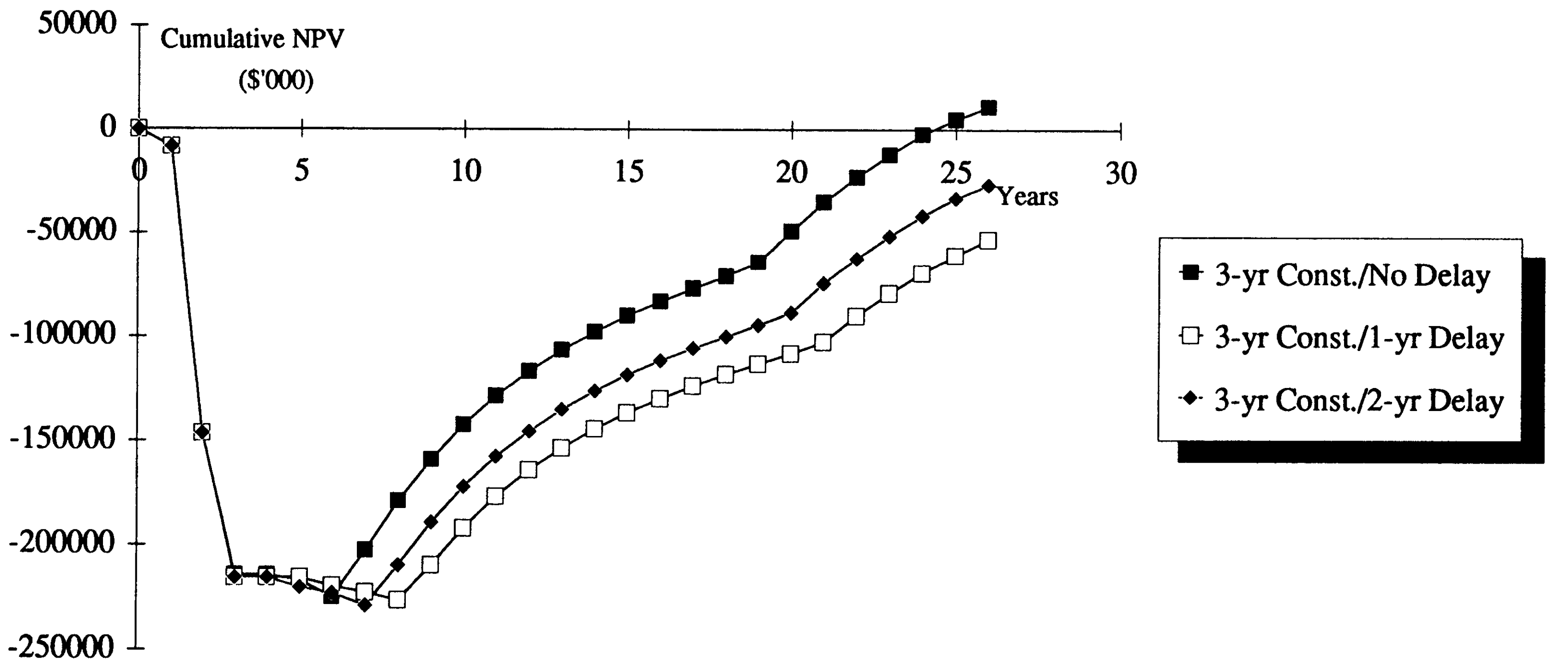


Figure 38. Sensitivity to Unleveraged Beta.

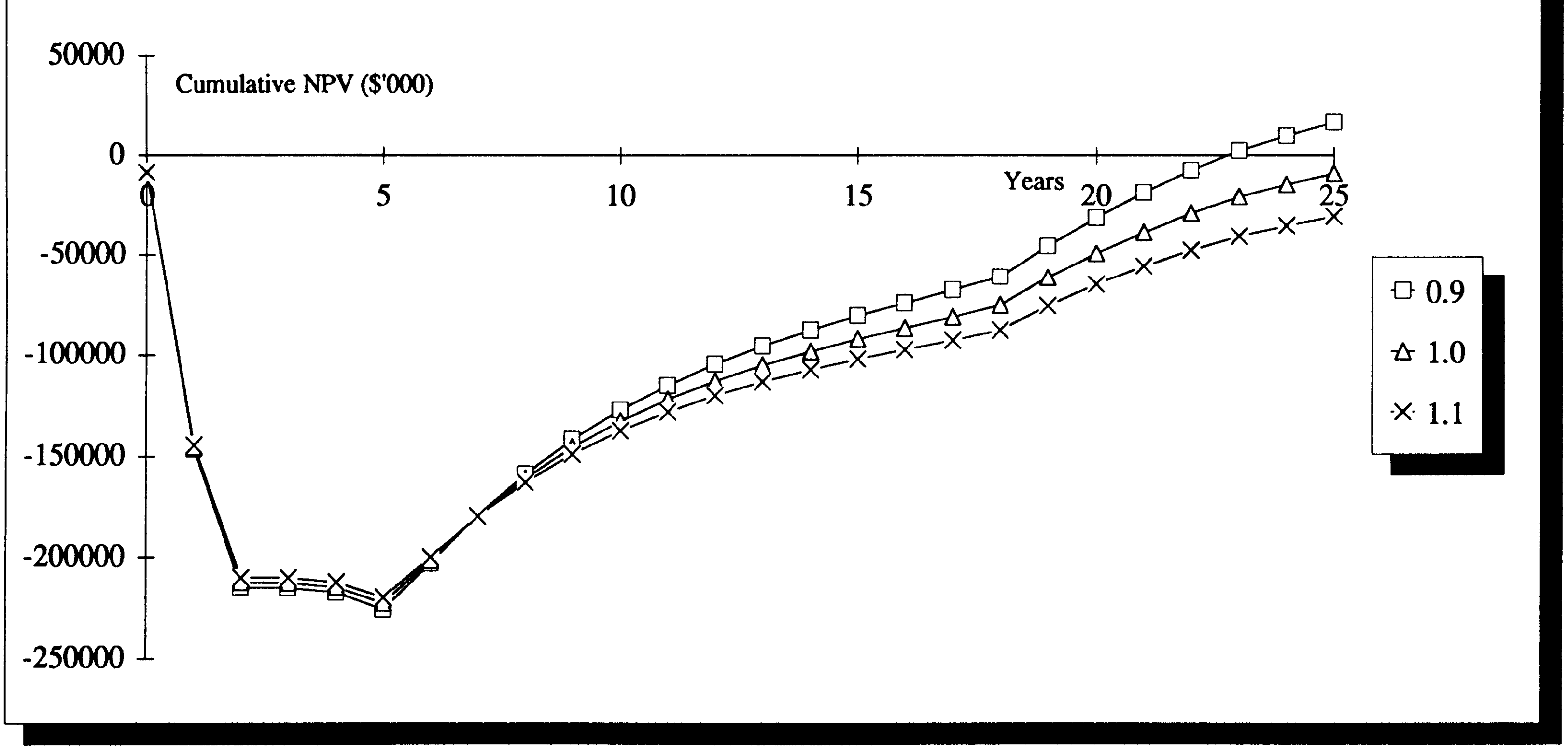


Figure 39. Sensitivity to Capacity Utilization.

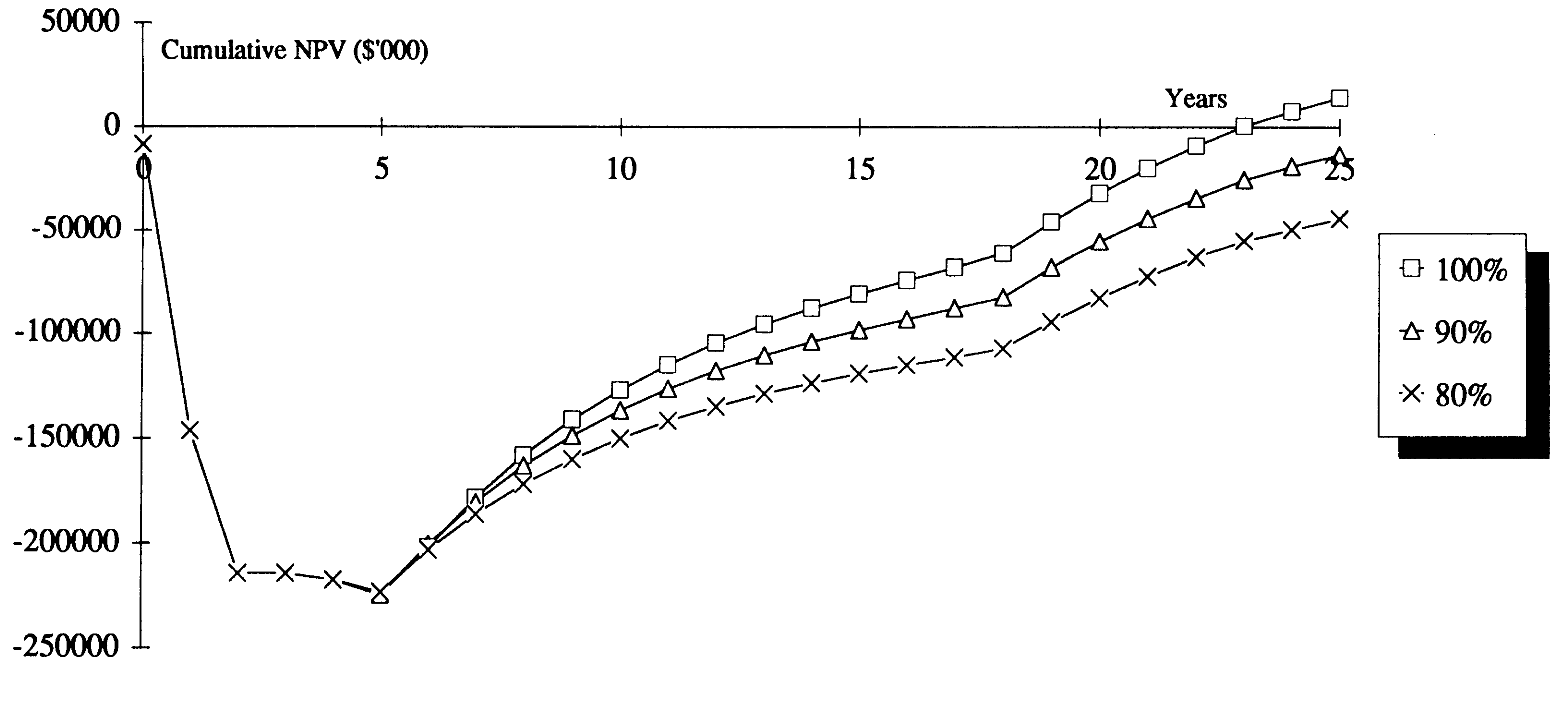


Figure 40. Sensitivity to interest Rate on Debt.

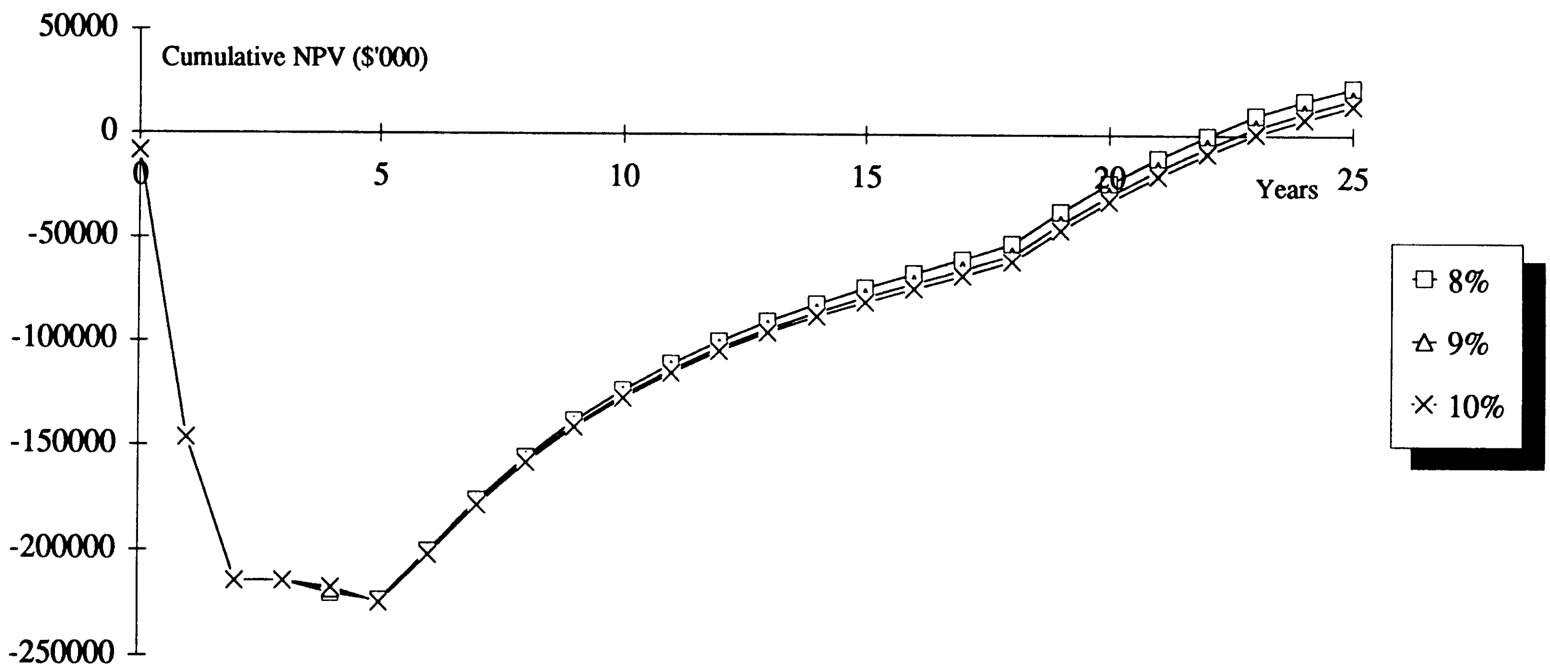


Figure 41. NPV for Different Investment Costs. Alumina Price $200/ton.Construction Period 3 yrs.

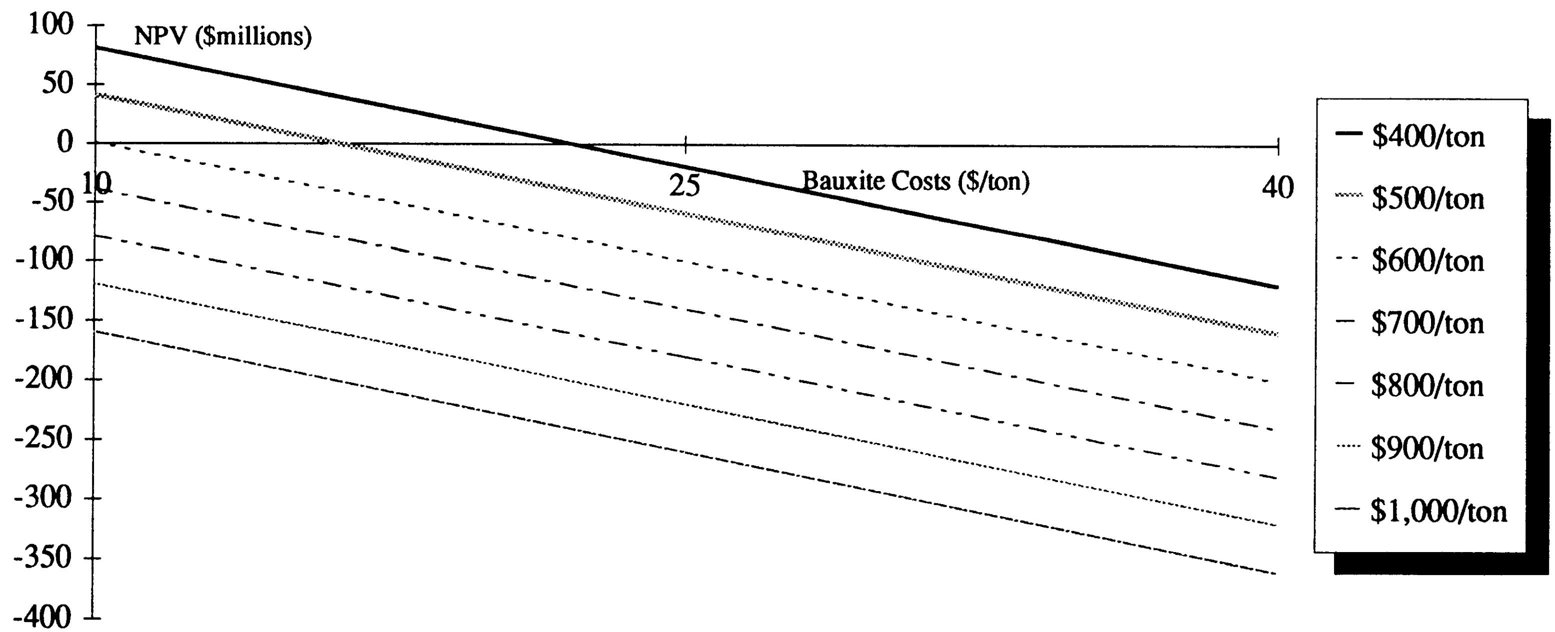


Figure 42. NPV for Different Investment Costs. Alumina Price $275/ton. Construction Period 3 yrs.

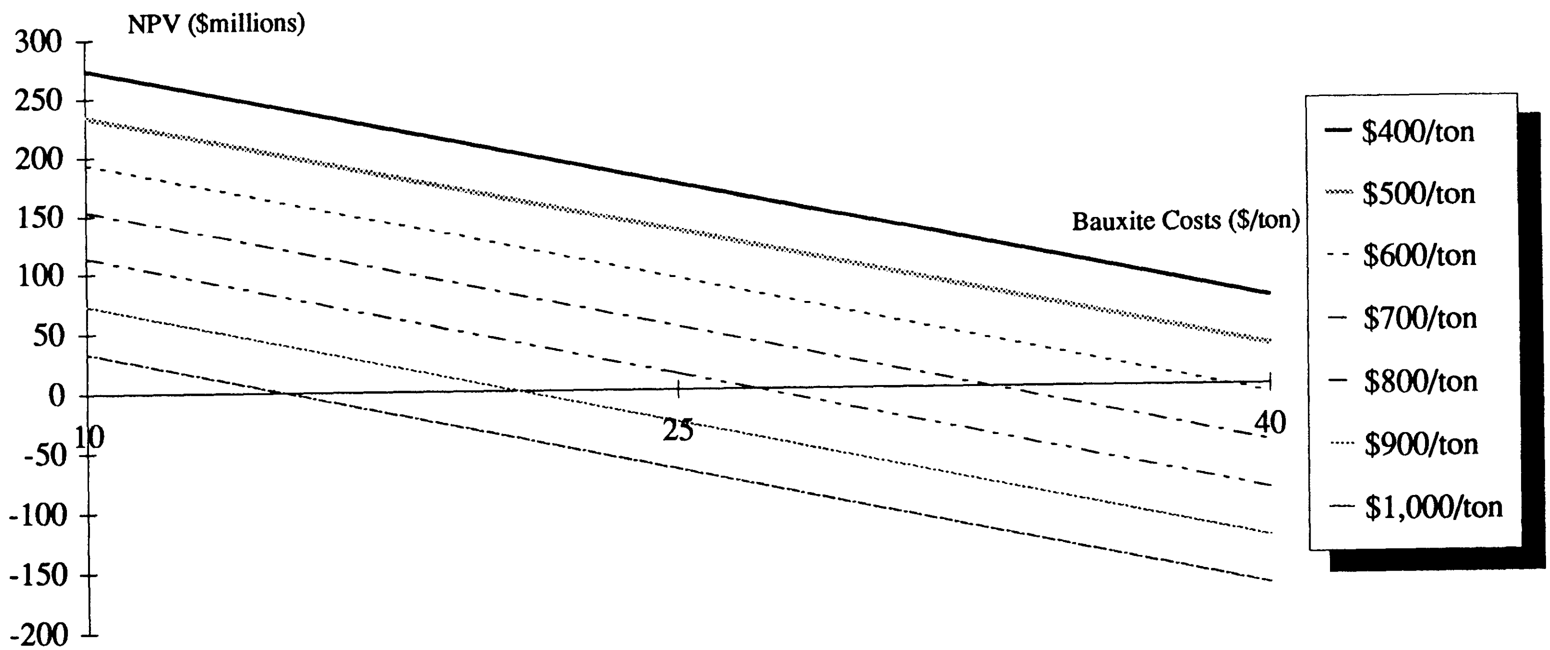


Figure 43. NPV for Different Bauxite Costs. Alumina Price $350/ton. Construction Period 3-yrs.

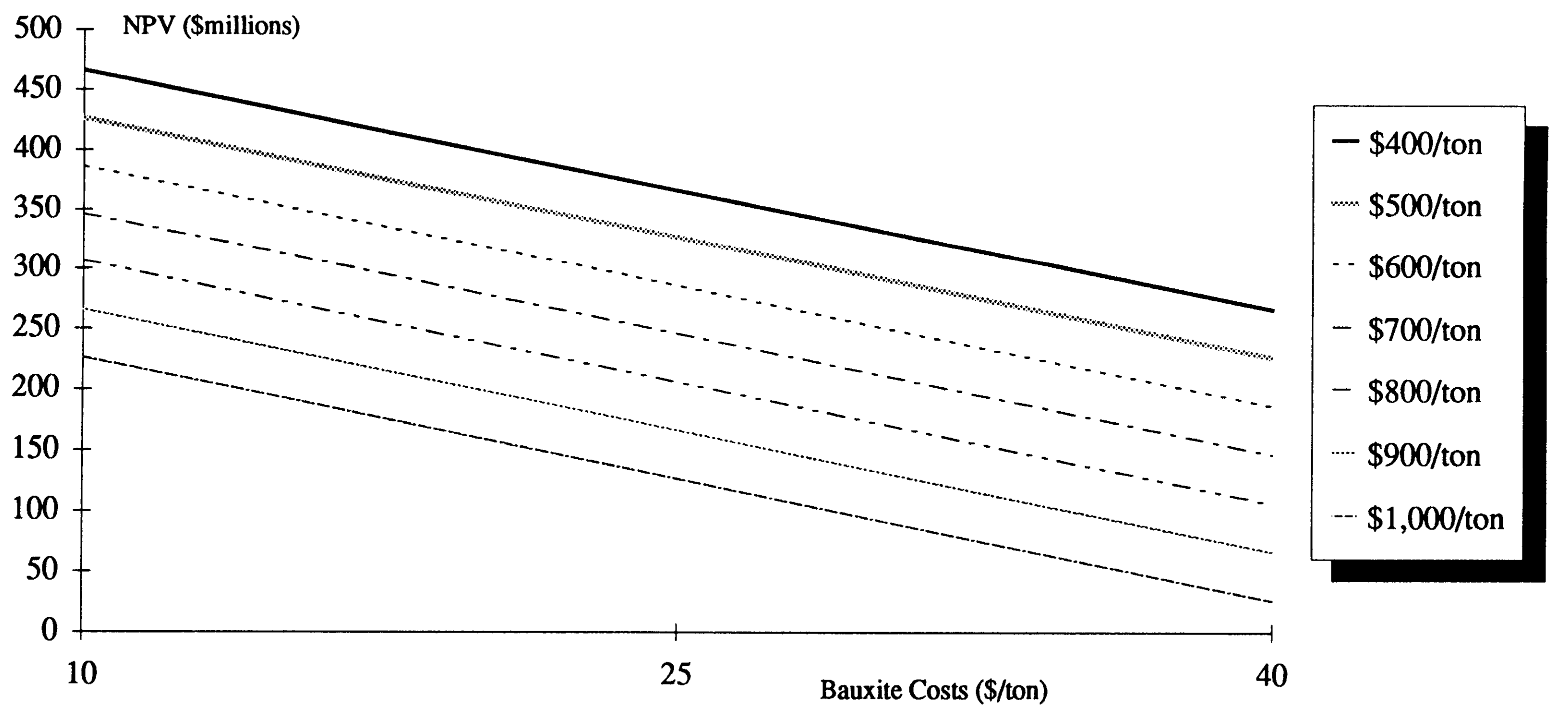


Figure 44. NPV for Different Investment Costs. Alumina Price $200/ton. Construction Period 5 yrs.

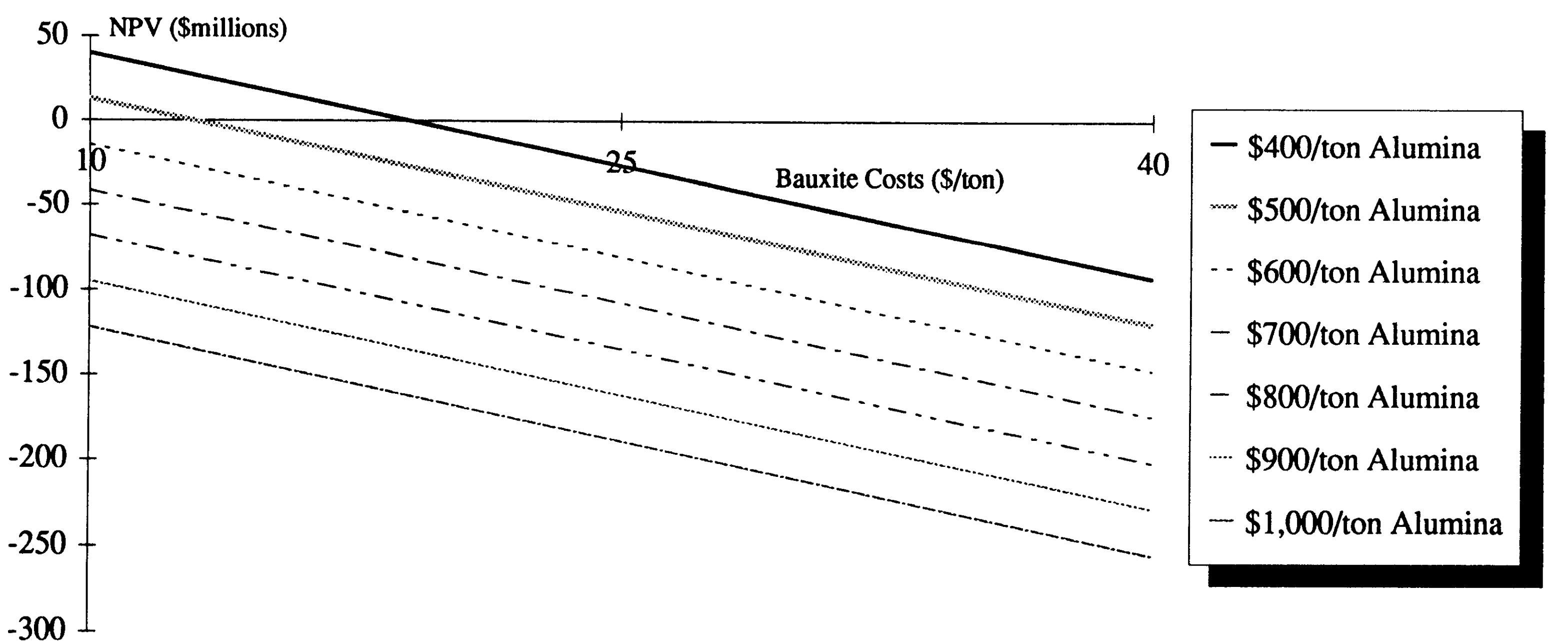


Figure 45. NPV for Different Investment Costs. Alumina Price $275/ton. Construction Period 5 yrs.

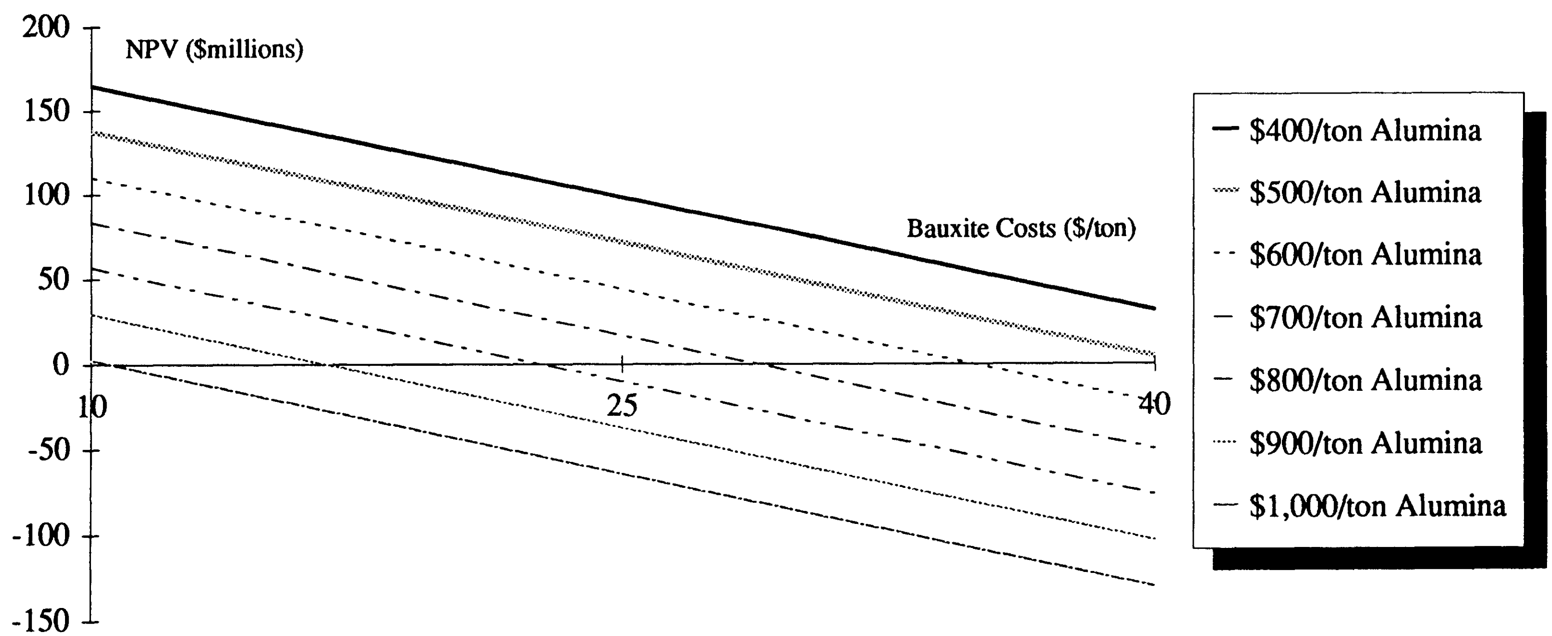
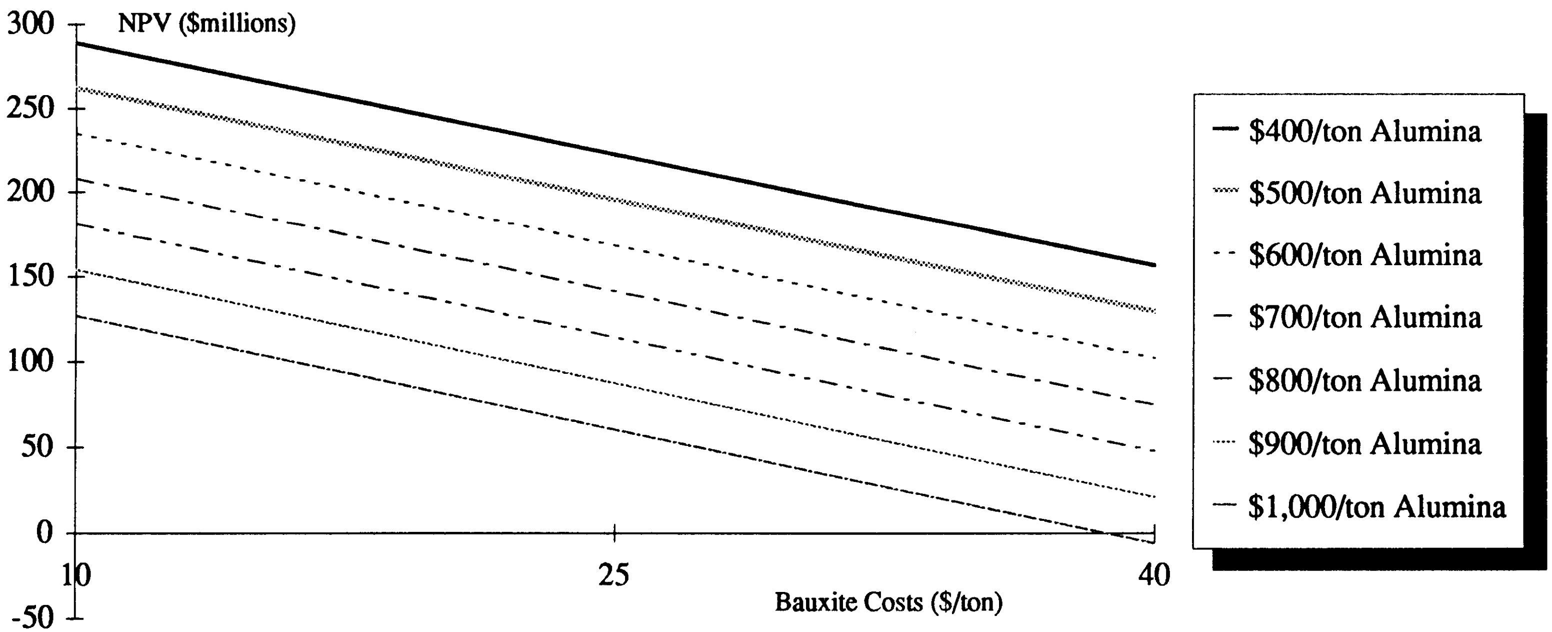


Figure 46. NPV for Different Investment Costs. Alumina Price $350/ton. Construction Period 5-yrs.



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