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Political Risk and The Trend of New Investment in the World Aluminum Industry

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The world aluminum industry will require significant expansion of capacity in mining, refining, and smelting by the year 2000. The World Bank has presented a cost model with the single objective of cost minimization. Concluding that the majority of new investment can be expected to occur in lesser developed countries. This study utilizes compromise programming to evaluate the impact of political risk as well as cost minimization. Consideration of risk modifies the World Bank forecast, resulting in increased expected investment in industrialized countries as risk consideration increased. This result compares favorably with actual investment trends observed.

I. Introduction

Forecasting economic developments is an increasingly important function for all market participants. This is particularly true for the investment trend and climate in the primary aluminum industry which is of concern to at least three groups of agents: First, the industrialized countries' governments due to the strategic nature of the metal; second, the multinational corporations

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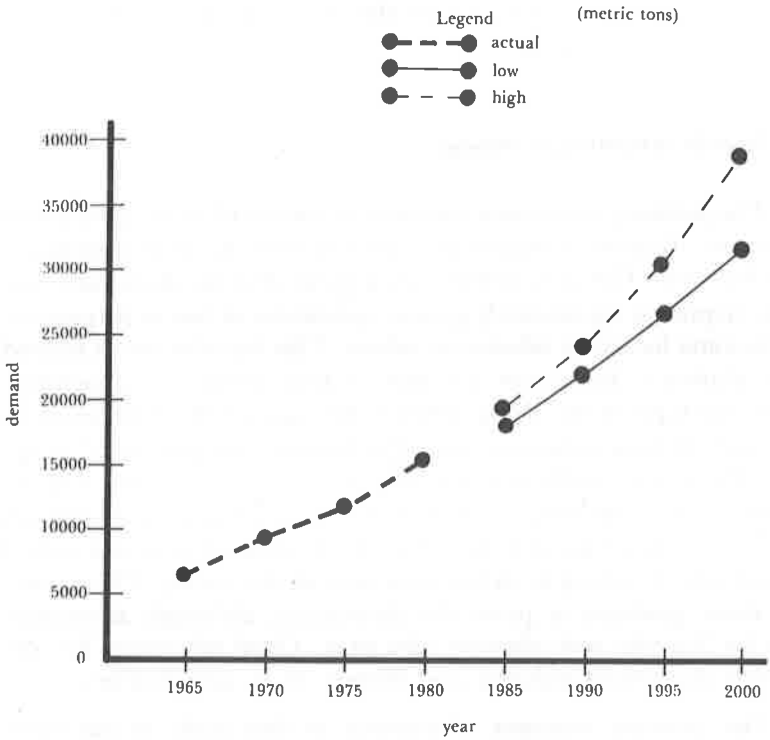
Figure 1

ALUMINUM DEMAND



Sources: Nonferrous Metal Date (annual)
Brown, et al. (1983), tables 3 and 4

ment the World Bank model. The technique used is compromise programming (Zeleny; Gearhart; Ecker and Shoemaker). This technique allows consideration of nondominated solutions which reflect various weightings of the alternative objective functions of cost minimization and risk minimization. While the result yields no predictive outcome, it does allow a measure of the tradeoff in outcomes between these conflicting objectives. This approach also reduces the difficulties in measuring political risk and cost on a common scale. While political risk is difficult to measure in terms of cost, it is more easily measured in an ordinal way.

Table 1

ALUMINUM INDUSTRY COUNTRIES BY SECTOR

LDC	Jamaica, Haiti/Domnican, Guyana, Surinam, Brazil, Venezuela, Ghana, Guinea, Sierra Leone, Cameroun, India Indonesia, Malaysia, Turkey, Mexico, Argentina, Egypt, Zaire, South Africa, ASEAN, Korea/Taiwan, Mideast
OECD	USA, West Europe, Australia, Canada, Japan
Other	East Europe, USSR, China

Source: Brown, et al.

gramming model. While production efficiencies do exist, the large impact of transportation, the limited capacities present in ore reserve capacities and smelting electricity, and the capital intensive nature of refining operations make the 0-1 model appropriate for the purpose of the model, which is to identify likely locations for increases in productive capacity. Because the purpose is to identify expected changes due to demand increases, existing facilities are constrained to at least current capacities. The aluminum industry has traditionally operated near full capacity, resorting to stockpiling rather than reducing operations during demand declines.

The variables of the model are:

For M mines (22 in the model)

X_m is current mine capacity

X_m* is new mine capacity

For R refineries (84 in the model by ore type)

X_r is current refinery capacity

X_r* is new refinery capacity

For S smelters (29 in the model)

X_s is current smelting capacity

X_{sl}* is new low cost electricity smelting

X_{sh}* is new high cost electricity smelting

For D demands (18 in the model)

DEM_d is expected aluminum demand in year 2000 by market

DEM_{bm} is expected nonaluminum demand for bauxite by mine in year 2000

DEM_{ar} is expected nonaluminum demand for alumina by

$C_{sl}*$ is the cost of smelting 1 mT at s using available low cost electricity
$C_{sh}*$ is the cost of smelting 1 mT at s with high cost electricity
C_{sd} is the shipping cost for 1 mT from s to d
F_m is the fixed cost for expanding mine m up to 16,000 kmt capacity
F_r is the fixed cost for expanding refinery r up to 2,000 kmt capacity
F_s is the fixed cost for expanding smelter s up to 200 kmt capacity

B. Constraints

For each mine m ($m = 1,\ldots,22$)

X_m = current capacity
$X_m* \leqslant 0.05$ reserve capacity

Balance between mine production and refinery production

$$X_m + X_m* = DEM_{bm} + \sum_{r=1}^{R} X_{mr}$$

For each refinery r ($r = 1,\ldots,84$)

$$\sum_{m=1}^{M} {}_m X_{mr} = X_r + X_r*$$

X_r = current capacity

$$X_r + X_r* = DEM_{ar} + \sum_{s=1}^{S} X_{rs}$$

For each smelter s ($s = 1,\ldots,29$)

$$\sum_{r=1}^{R} {}_r X_{rs} = X_s + X_{s1}* + X_{sh}*$$

X_s = current capacity
$X_{s1}^* \leqslant$ available low cost capacity

$$x_s + X_{s1}* + X_{sh}* = \sum_{d=1}^{D} X_{sd}$$

For each each demand D ($d = 1,\ldots,18$)

Table 2

COMPARISON OF COST MINIMIZATION MODELS: PROPORTIONATE SHARE OF NEW INVESTMENT

	LDC	OECD	East Europe/ China
Mines			
0-1 Model	1.00	0	0
Network Model	.98	0	.02
Refineries			
0-1 Model	.71	.15	.15
Network Model	.94	.06	0
Smelters			
0-1 Model	.69	.22	.09
Network Model	.71	.04	.26

lem for the domestic firm, runs into theoretical and practical difficulties in the international context. This is particularly true for firms operating in developing countries with more or less rudimentary financial markets. Besides, modern international capital asset pricing models (ICAPM) in general assume that risks such as expropriation, currency control and foreign exchange changes, are nonsystematic (and therefore not priced) (Grauer, Litzenberger and Stehle).[3] However, surveys and case studies of multinational corporations have indicated that in addition to profit maximization, political risk does play an important role in capital budgeting decisions (Bhalla; Blank, et al.; Haendel, et al.; Harnes; Kobrin; Loewinger; Radetzki and Zorn). That is, corporations base their investment decision based on the total (systematic and unsystematic) risk of the project rather than on the systematic component. Furthermore, in the assessment of the riskiness of alternative projects in the international context, the

[3] ICAPM also yield that foreign investment may *reduce* the systematic risk by supplying international diversification. This result may hold for a number of possible distributions of investments abroad, and it is possible to conceive a particular distribution of investment locations that optimizes the risk-return tradeoff function of the MNC.

Table 3

EXPROPRIATION BY INDUSTRY GROUP, 1960-1974

Industry	Number of Expropriations	Percent of Total
Oil	84	12.0
Extraction	38	18.0
Utilities and Transportation	17	4.0
Insurance and Banking	33	4.0
Manufacturing	30	1.2
Agriculture	19	n.a.*
Sales and Services	16	n.a.*
Land, Property and Construction	23	n.a.*

*n.a.: not available
Source: Bradley

panel of experts. These methods assess environmental factors like political stability, economic growth, attitude toward foreign investment, and so forth. The panelists score each factor and the results are aggregated using different weights. The resulting index gives a measure of political risk of a country.

A second group of methodologies uses indices built on quantitative indicators. Several of these indices are available. One of the most sophisticated ones is the "Political System Stability Index" (PSSI) prepared by Haendel, West and Meadow. Rather than relying on "soft" opinion measures, the PSSI is based on "hard" data. PSSI is composed of three equally weighted indices, all of which include indicators bearing on the stability of the political system: (1) the Socioeconomic Index; (2) the Governmental Processes Index; and (3) the Societal Conflict Index.

Bhalla[4] published a foreign investment risk matrix prepared for 114 market-oriented countries. Each country was rated on a risk matrix for short and long term political and economic factors. Political risk was assessed in terms of the stability of the govern-

4 Bhalla's risk matrix was originally prepared for use in the packaging industry. However, the rating was generated, taking into account factors affecting the manufacturing sector in general. Thus, its employment to evaluate the aluminum industry is as legitimate as that of any other index available in the market at the time of the study.

IV. Network Compromise Programming

Compromise programming provides a means of identifying expected investment given varying emphases upon cost and risk. A key concept used in this study is that of a nondominated solution. A solution is nondominated if no other solution has a preferable cost and risk result at the same time. The use of linear programming models will yield nondominated solutions when weighted combinations of a combined objective function are used (Zeleny, 1973).

A network flow model was run with objective function reflecting cost. This solution yielded the worst nondominated measure of risk. Then a series of models reflecting weighted combinations of the risk function and the cost function were run. It was necessary to use a weighted combination because a number of solutions yield the same risk. To assure nondominance, cost must be considered at least a small value to select between alternative low risk solutions. The risk function minimized was:

$$\text{Min } Z_r = \sum_{m=1}^{M} X_m{}^* \, \sigma_m C_{capm} + \sum_{r=1}^{R} X_r{}^* \, \sigma_r C_{capr} + \sum_{s=1}^{S} X_{sl}{}^* \, \sigma_x C_{caps} + \sum_{s=1}^{S} X_{sh}{}^* \, \sigma_s C_{caps}$$

where σ_m is the risk associated with mine m

σ_r is the risk associated with refinery r

σ_x is the risk associated with smelter s

C_{capm} is the capital cost per T at mine m (a component of C_m)

C_{capr} is the capital cost per T at refinery r (a component of C_r)

C_{caps} is the capital cost per T at smelter s (a component of $C_{sl}{}^*$ or $C_{sh}{}^*$)

The overall function minimized:

$$\text{Min } Z = (1\text{-}\alpha)Z_c + \alpha Z_r$$

where α is the risk weight ($0 \leqslant \alpha \leqslant 1.0$)

Once the cost minimization solution and the risk minimization solutions were obtained, the attainment of both objectives could be measured proportionately. Each intermediate solution can be evaluated in terms of the relative sacrifice of cost and risk between tion reflecting selected α, reflecting the resulting cost and risk functions. Then this input file was optimized with a network optimizer. Additional computer codes interpreted the resulting solution, calculated resulting cost and risk, and generated a detailed report of all variables. This last report code also added the fixed costs for expanded facilities in order to check for severe impact of omitting the 0-1 constraints in the algorithm model. As all costs for rising were greater, no severely apparent impact was detected.

V. Results

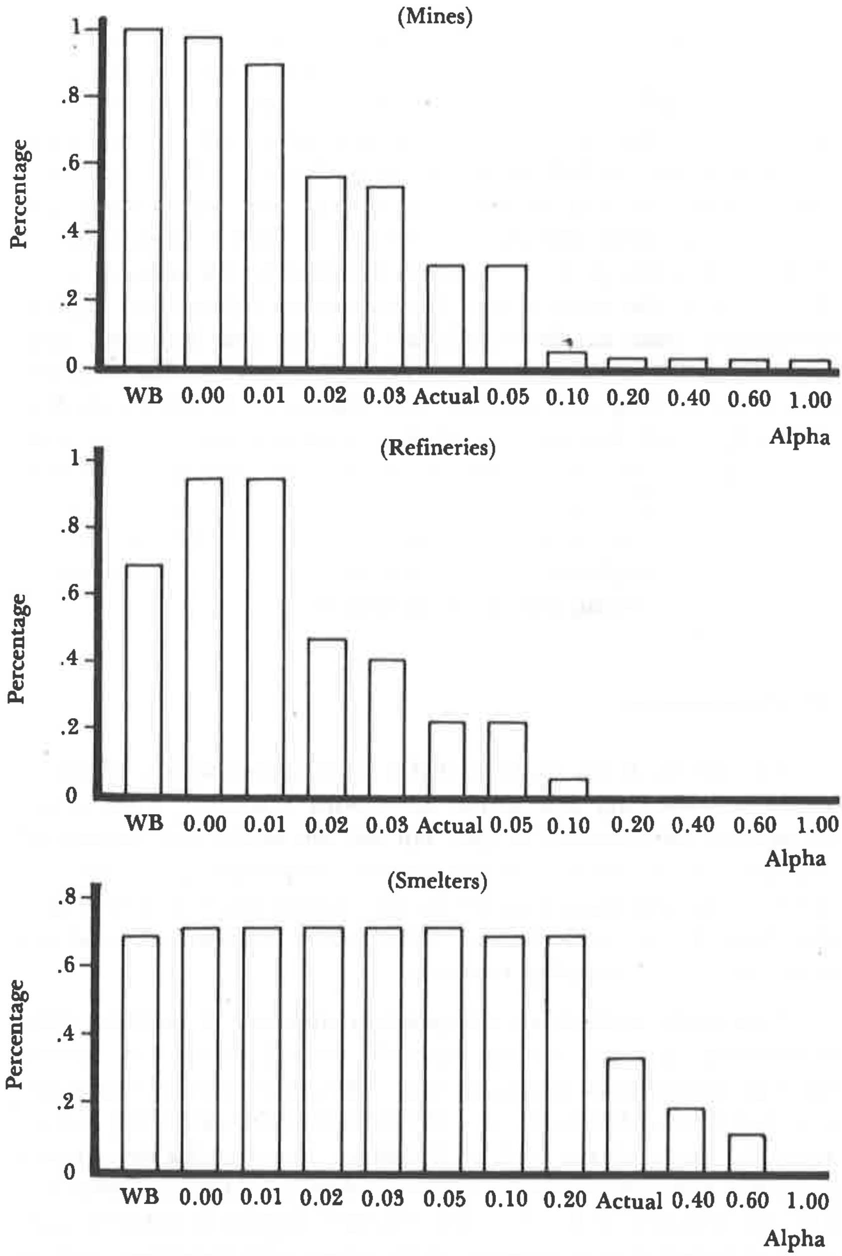
The tradeoff between cost and risk minimization presents a contingent series of solutions rather than a single solution. The cost minimization solution given by the World Bank study provides an indication of potential for higher profit, although risk involved to investors was not considered. The solutions obtained in this study indicate that as risk becomes more important, investment sites other than low cost sites become more attractive. This is due in large part to the small marginal costs often associated with alternative investment sites. The argument of this paper is that investors would make a risk assessment based upon current conditions. If general economic and political conditions were stable, we would expect movement towards the cost minimization solution. On the other hand, if risk were more important due to turbulence, political or economic, we would expect a shift in investment toward less risky sites.

A. Actual Investment Patterns

The solutions obtained in this study reflect extremes at the cost minimization end (increased investment in LDCs) and the risk minimization end (increased investment in OECD). Varying the risk level yields a number of sites that do not appear in either extreme case. One measure of what is likely to occur is the increases in investment between 1970 and committed investments as of 1980. Mikessel observed that between 1966 and 1977, the book value of US investment in all mining and smelting operations in LDCs dropped from 42 percent to 32 percent of total US investment in mines and smelters. Within the aluminum industry, World Bank data indicates that the share of investment in LDCs was 34 percent

Figure 3

THIRD WORLD EXPANSION 1980 TO 2000



well as moderate risk can be expected to receive the bulk of future investment in the growing primary aluminum industry.

The risk measure used in this study was selected as an independent ranking of risk by international finance professionals. It is expected that actual risk to investors would be dynamic, as well as varying by investor. But our point is that while cost minimization models identify economically efficient sites available for capacity increases, actual investment would be expected to be heavily influenced by political risk perception. This would likely lessen the proportion of investment in developing countries.

References

Bhalla, B., "How corporations should weigh up country risk," *Euromoney*, June, 1983, 66-72.

Blank, S., et al., *Assessing the Political Environment: An Emerging Function in International Companies,* The Conference Board, New York, 1980.

Bradley, D., "Managing against Expropriation," *Harvard Business Review*, July/Aug., 1977, 75-83.

Brown, M., et al., *Worldwide Investment Analysis: The Case of Aluminum,* World Bank Staff Working Paper, 603, The World Bank, Washington, 1983.

Ecker, J.G. and N.E. Shoemaker, "Multiple Objective Linear Programming and the Tradeoff Compromise Set," Fandel, G. and T. Gal, eds., *Multiple Criteria Decision Making Theory and Application,* Springer Verlag, New York, 1979, 60-73.

Gearhart, W.B., "Compromise Solutions and Estimation of the Noninferior Set," *Journal of Optimization Theory and Applications*, 28, 1979, 29-47.

Grauer, F.L.A., Litzenberger, R.H. and R.E. Stehle, "Sharing Rules and Equilibrium in an International Capital Market under Uncertainty," *Journal of Financial Economics*, 3, 1976, 233-256.

Haendel, D., Gerald, G.T. and R.G. Meadow, *Overseas Investment and Political Risk,* MA: Lexington Books, Lexington, 1975.

Harnes, F.T., *Construction and Forecast Techniques for a Measure of a Country's Willingness and Capacity to Permit Repatriation of Funds,* Beri Ltd., New York, 1981.

Kobrin, S.J., "Political Risk: A Review and Reconsideration," *Journal of International Business Studies*, Spring/Summer, 1979, 67-80.