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Planning for Future Ferroalloy Production in South Africa

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Planning for long-term projects such as the establishment of new ferroalloy plants necessitates proper environmental scanning that will identify the strategic factors determining a project's feasibility. Once identified, these factors need to be placed in a proper strategic-planning framework, and then analysed as to their relative importance in determining economic feasibility.

The strategic factors identified in the external societal environment are market opportunities, local market interdependence, international trade, and exchange rates. In the external task environment, actions by the State, and capital and production costs are the major determinants of a project's feasibility. Mineral raw materials, industry structure, manpower, and technology are the factors in the internal business environment warranting priority attention when future ferroalloy ventures are planned.

South Africa, with its vast reserves of economically exploitable ferrous-metal ores and coal, has the potential to substantially expand its production of ferroalloys. The proper planning for such expansions will ensure that this potential is turned into reality.

Introduction

An economic analysis of ferroalloy production has identified the key success factors that determine financial and competitive feasibility. These factors, known as strategic factors, indicate those aspects which need priority attention when industrial expansions are contemplated. The barriers of entry into ferroalloy production are primarily access to the markets and an understanding of how they operate, secure access to raw materials, know-how, skilled personnel, and availability of capital.

This paper identifies the factors determining the feasibility of future ferroalloy ventures in South Africa and proposes a strategic-planning framework that incorporates these strategic factors.

Theoretical Evaluation

Economic theory facilitates a better understanding of the determinants influencing the establishment of new ferroalloy production capacity. Of particular interest in this respect are the modern dynamic trade theories, the theory of mineral supply, and the location theory.

Modern Dynamic Trade Theories

Modern trade theories such as the technology-gap, product-lifecycle, and scale-economy theories are also known as the neo-technology theories. They refer to technological differences between trading partners in explaining trade patterns[1]. These theories also shed some light on the feasibility of future industrial expansions in different economic regions.

The neo-technology theories recognize influences affecting trade patterns. Such influences involve mainly the differences between countries in efficiency and technology, like the introduction of new and improved products and processes, and the realization of scale economies in the domestic market.

The dramatic growth in the South African ferrochromium industry supports the theory that technological change will change trade patterns. The advent of the argon–oxygen decarburization (AOD) process in stainless-steel production made it possible to utilize charge chromium produced from low-grade South African chromites. Prior to this technological breakthrough, the suitability of local chromium ores for the production of stainless steel was limited by their low chromium-to-iron ratios.

If South African companies are prepared to invest in technology, the neo-technology trade theories suggest that they could successfully establish additional ferroalloy production capacity to supply the international market. These theories, however, also suggest that the availability of vast local ore deposits alone does not give local beneficiators a comparative advantage in supplying refined commodities. The considerable tonnages of byproduct chromite fines generated by platinum producers mining the UG-2 Reef have little economic value unless technology is developed to enable them to utilize these reserves. The answer might lie in perfecting the Plasmasmelt technology. Only by employing the best technology and ensuring that optimal production efficiency is maintained can local producers hope to compete successfully on the international market.

Theory of Mineral Supply

The opinion is often expressed that South Africa's mineral resources are scarce in an absolute physical sense, and that the free market cannot be relied upon to facilitate an equitable intertemporal distribution of economic rents accrued from such resources over time. This has led to widespread support of some form of intervention to regulate the production and trade of mineral resources. State incentives encouraging some sectors of the industry and trade restrictions on mineral commodities, such as the export quota system for South African coal, were based on this concept.

However, the theory of mineral supply implies that a system of competitive markets will establish incentives, such as the expectation of future increases in mineral prices, for delaying mineral production into the future, and therefore preserving mineral resources for future generations. Without continued market imperfections, it would therefore not be necessary for the State to interfere in the minerals industry in order to ensure the equitable and efficient utilization of South Africa's mineral resources.

The theory of mineral supply thus predicts an eventual increase in the prices of ferrous-metal ores as a result of the exhaustion of the current shallow, high-grade mines. For producers of ferroalloys in South Africa, backed by vast reserves of easily mineable chromium, manganese, and vanadium ores, this may be a positive scenario if they can contain the cost of raw materials more effectively than their overseas competitors. For integrated firms active in both mining and ferroalloy production, containment of ore costs should be considerably less arduous than for overseas importers of raw materials.

However, the relatively low prices obtained for mineral raw materials, reflected by the deteriorating terms of trade of the countries exporting raw materials, indicate that market imperfections exist, causing mineral raw materials to be sold at depressed prices. From Table I the deterioration of South Africa's terms of trade over the past two decades is clearly evident. During the 1970's, the country's non-gold terms of trade deteriorated from an index value of 152,5 in 1970 to 115,3 in 1979, while the 1980's saw a relative stabilization around a value of 100. The ratio at which this country can acquire manufactured imports for raw-material exports has thus declined markedly over this period.

An obvious solution to the problem of too cheap raw materials on world markets would be to beneficiate the minerals prior to export. The value added to a commodity through successive stages of beneficiation can be substantial. The successive stages of beneficiation of chromite to ferritic stainless steel, for example, increase[2] the value of the chromium content by a factor of 300. By exporting predominantly beneficiated commodities and manufactured articles, South Africa would improve its terms of trade significantly.

Location Theory

According to the location theory, plant location is dictated both by production-cost advantages at a particular site and by the proximity of industries consuming the product manufactured by the plant. If this theory is to hold for ferroalloy production, the first criterion would be a location offering cheap sources of raw materials and electricity.

TABLE I
SOUTH AFRICA'S TERMS OF TRADE (1985 = 100)

Year	Excluding gold	Including gold
1970	152,9	84,4
1971	145,2	86,1
1972	136,6	91,8
1973	148,5	110,6
1974	144,0	120,1
1975	132,1	107,6
1976	127,9	96,3
1977	127,9	99,3
1978	124,1	101,3
1979	115,3	106,9
1980	107,2	119,2
1981	105,7	105,3
1982	95,1	92,5
1983	99,1	97,6
1984	101,4	98,6
1985	100,0	100,0
1986	99,1	100,3
1987	98,7	102,1

Source: South African Reserve Bank (1975–1988). *Quarterly Bulletin*, various issues

Least-cost considerations played a dominant role in the location of the ferroalloy plants established in South Africa. Relatively low electricity tariffs, proximity to metal-ore deposits reducing mine-to-plant transportation costs, infrastructure, and labour sources were important considerations in the location of such facilities. Ever-increasing transportation costs, especially for high-bulk metal-ores, may cause such plants to be established closer to the metal ore deposits in future. Table II shows how the escalation of rail tariffs for chromium ore outstripped the inflation rate during the 1970's and 1980's.

With the move towards privatization of South African rail services, the cross-subsidization of rail tariffs has fallen

TABLE II
EXPORT RAIL TARIFFS FOR CHROMIUM ORE VERSUS CONSUMER PRICES

Year	Tariff		Consumer prices	
	R/t	Change %	Index	Change %
1976	7,22	32,70	62,9	10,94
1977	8,84	22,40	70,0	11,35
1978	9,86	11,50	77,6	10,88
1979	11,22	13,80	87,9	13,22
1980	13,20	17,60	100,0	13,79
1981	15,30	15,90	115,2	15,21
1982	18,40	20,30	132,1	14,68
1983	21,80	18,50	148,4	12,31
1984	24,90	14,20	165,7	11,66
1985	29,70	19,30	192,6	16,22
1986	37,20	25,30	228,5	18,64
1987	42,30	13,70	265,7	16,30

Source: Robinson, I.C. (1987). p. 139

away. Through this system, the erstwhile South African transport services subsidized the transportation of low-value ferrous metal ores from large profits on the transportation of low-bulk higher-valued commodities such as ferroalloys, on the principle of charging what the product could bear. The location of the most recent ferrochromium plants close to the chromium mines near Rustenburg, and of Samancor's manganese sinter plant at the Mamatwan Mine, are cases in point.

The impact of a local consuming market on the location of ferroalloy plants in South Africa is exhibited in the establishment of a ferrosilicon dense-medium plant to serve the local mining industry. The need for improved methods of diamond recovery provided the initial stimulus on which a whole new industry was founded in South Africa[3]. The proximity of a consuming market appears to have been an incentive to initially locate ferroalloy plants close to steel mills in the industrialized countries. Higher transportation costs for higher-value commodities and better consumer–producer liaison between firms situated in the same country may have been the reasons for this.

Strategic Factors

Prior to engaging in ferroalloy ventures, entrepreneurs have to scan the external business environment in order to identify possible opportunities and threats, and the internal environment to identify strengths and weaknesses. Environmental scanning comprises the monitoring and analysis of information from the economic environment in which a company will operate, and the dissemination of the information to key personnel within the company[4]. It is a technique that can be used in order to avoid strategic surprise and to ensure long-term economic feasibility.

The environmental variables that are the most important to the economic feasibility of future ferrous-metal beneficiation projects are referred to as strategic factors. It is the object of this paper to identify and to analyse these strategic factors that will enable the entrepreneur to formulate a strategy for the establishment of a ferroalloy project. Figure 1 lists the ten identified strategic factors impacting on the ferroalloy industry in a strategic planning framework. Seven of these factors are in the external economic environment, while three are within the internal environment of the industry.

The four strategic factors in the societal environment represent the variables that do not influence the short-term activities of the ferroalloy industry, but that impact on long-term decisions. Market opportunities for ferroalloys and the role of the domestic consumption of carbon- and speciality steel goods are influencing long-term projections of the feasibility of future beneficiation projects. Similarly, the international market, where commodity trade patterns and exchange rates are determined, impacts on the long-term fortunes of the industry outside the control of management.

The task environment consists of three factors that directly affect their beneficiation industry's major operations through the influence on the physical and financial infrastructure, and the availability and cost of productive factors. State actions, the availability and cost of capital, and future production-cost variables not within the short-term control of management make up this category of the external environment of the ferroalloy industry.

Mineral raw materials, the structure of the ferrous-metal beneficiation industry, manpower, and technology

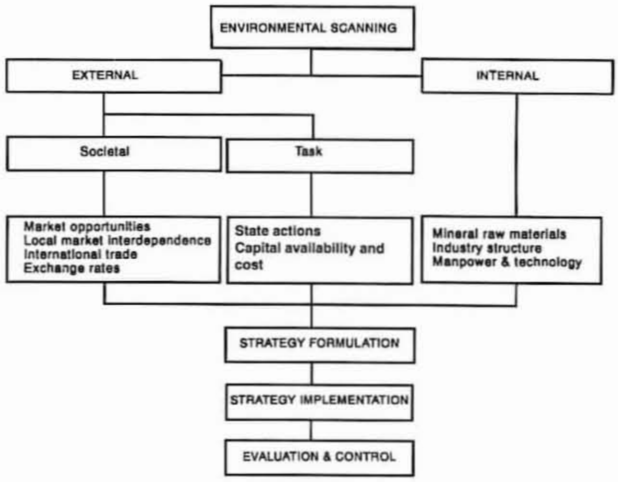

FIGURE 1. A strategic management model for ferroalloy production

represent the strategic factors within the industry that constitute the internal environment. These variables are typically within the short-term control of management, such as a decision to extend existing ore capacity through investment in exploration or extensions in mine infrastructure.

The strategic factors, which have been discussed in the larger strategic-planning structure, have now to be scrutinized in order to evaluate their possible impact on a proposed ferroalloy venture. Following the structure explained in Figure 1, each of these factors will now be discussed with the planning for future ferroalloy ventures in mind.

Market Opportunities

The static demand for steel over the past two decades connotes limited prospects of market growth for ferroalloys in future. While the industrialized nations have reached saturation in steel-consuming industries, most of the developing nations struggle to reach the level of economic development at which the intensity of steel consumption will reach the levels seen in the industrialized nations during their primary growth periods[5]. Increased demand in the traditional steel markets thus appears to be unlikely for some time to come.

Innovation in product range and marketing techniques, however, can reverse this static trend in steel demand. New applications for existing materials and new alloys, such as chromium–manganese corrosion-resistant steels substituting for both carbon- and stainless steel, can open up vast new markets for some ferroalloys. An opportunity for market penetration by lower-cost corrosion-resistant steels such as 3CR12 is the so-called performance gap, which refers to the market for a steel with a corrosion resistance superior to that of carbon steel but inferior to that of austenitic stainless steel. This concept identifies the opportunity for corrosion-resistant steel to progressively substitute for carbon steel up to a level of 5 per cent, i.e. more than 30 Mt over a period of 25 years[6].

With changes in the international market, opportunities will open up to exploit niche markets in the production of proprietary alloys and semi-manufactured goods. The capital intensity and large economies of scale of ferroalloy and steel production favour the existing producers for future expansions. The barriers to entry for relatively small newcomers to these activities restrict their participation mainly to mining and the fabrication of final products.

However, opportunities exist for smaller risk-taking entrepreneurs to exploit innovative financing, management, and marketing strategies to establish new ferroalloy ventures. John Vorster's Chromecorp Technology and Vanadium Technology are examples of this type of venture. Once they have been proved to be economically feasible, the larger institutions may choose to take over such operations, as happened in the cases of Batlhako and Purity.

Local Market Interdependence

The shift of ferroalloy production capacity away from consumption centres in industrialized countries suggests that local-market interdependence no longer plays a very important role in the location of ferroalloy plants. The availability of smelting technology and efforts towards the minimization of production costs have played a more important role in the location of ferroalloy plants over the past two decades.

However, for the fabrication of ferrous-metal consumer articles, the presence of a domestic market proves to be a determining factor for the economic feasibility of a beneficiation industry. Such a market not only provides a secure outlet for sales; it is also conducive to the development of the technological and marketing know-how necessary to penetrate export markets[7].

The locational interdependence of firms or demand forces is evident in the local market for mining equipment and for the materials consumed in mining and minerals processing. Atomized and milled ferrosilicon were developed in South Africa for the dense-medium separation of heavy minerals such as diamonds and andalusite. Opportunities for supplying the extensive local mining industry with corrosion-resistant steel could be investigated for future niche markets. In 1989, the gold mines who are members of the Chamber of Mines consumed 37,4 million rands' worth of steel sections, of which only 4 per cent was stainless steel[8].

International Trade Patterns

The consumption of ferroalloys in South Africa is very limited compared with that of the world as a whole. Mineral-beneficiation operations typically exhibit large economies of scale, necessitating marketing on the larger international market. International trading in ferroalloys ensures the economic feasibility of mining and beneficiation activities in South Africa. In order to optimize the gains from the country's natural resources in the form of vast ore deposits, a sophisticated marketing strategy for ferroalloys needs to be planned and executed.

The deteriorating terms of trade faced by exporters of raw materials point to the urgent need for a strategy of beneficiation prior to export. South Africa's poor economic growth over the past decade, coupled with the need for employment opportunities and economic advancement of the masses, necessitates a policy of adding value to exports. Economic aspirations kindled by political reform will have to be addressed in the short term. Policies on inward industrialization alone will not enable this country to acquire wealth-generating capital equipment from abroad.

Exchange Rates

A deteriorating rand exchange rate during the 1980's was a mixed blessing for ferroalloy producers in South Africa. Over this period, the rand was devalued far more than was necessary to offset the rise of the domestic inflation rate, mainly due to a deterioration in the country's international political standing. While this impacted positively on the rand returns from ferroalloy exports, it had the opposite effect on the rand costs of capital-equipment imports to sustain the growth of ferroalloy production capacity. The economic feasibility of greenfields ferroalloy ventures, by new entrants in particular, was compromised by a deteriorating rand exchange rate.

Furthermore, South African firms have had to contend with an exceptionally unstable rand exchange rate since the rand was allowed to float freely in September 1983. Exchange-rate movements in excess of 5 per cent have occurred on single days since the inception of the freely floating rand. Volatile exchange rates create an element of uncertainty in projecting future income and expenditure scenarios, which in turn cast a doubt on project feasibility. By stabilizing the rand exchange rates, the South African authorities could create an environment more conducive to future expanded ferroalloy production.

State Actions

The role of the State in future ferroalloy projects should primarily be that of creating a level of competence in the national labour force to support an expanded ferrous-metal beneficiation industry. The allocation of resources to the training and schooling of technologists and engineers will achieve more in promoting exports of value-added products than expensive export incentives.

Such incentives have failed to play a major role in the establishment of new ferroalloy plants[9]. A recent study by the National Productivity Institute showed that 85 per cent of the companies surveyed were not motivated to export by the General Export Incentive Scheme, and 95 per cent indicated that they rely on their own efforts to secure export orders[10]. The companies surveyed included prominent ferroalloy and steel producers of South Africa.

Feasibility studies into the establishment of multi-million rand projects such as ferroalloy smelters tend to concentrate on sound economic factors such as production costs and market opportunities, with State incentives regarded only as marginally influential variables. Apart from creating a domestic level of competence, the State could create an economic milieu conducive to the establishment of beneficiation activities by relaxing regulatory restrictions on fabricating activities. Small-scale fabricators of steel commodities may well be the ultimate incentive for local ferroalloy production.

Capital Availability and Cost

Capital scarcity for long-term capital-intensive investments may prove to be one of the major constraining factors of an expanded ferroalloy industry in South Africa. A flight of capital due to economic sanctions and low real domestic interest rates resulting from State manipulation have to be countered to resolve this problem. Existing corporations in the ferroalloy industry utilizing retained earnings therefore have little competition from newcomers, creating a monopolistic structure.

Relatively high levels of investor expectations and corporate tax rates cause the cost of capital in South Africa to be higher than in most of the other major ferroalloy producing countries. According to a study by the South African Chamber of Business, the cost of capital in South

Africa is 31,1 per cent, which means that, for each R1000 used in the funding of working capital and capital stock, a margin of R311 would be required to service the cost of capital[11]. This compares with 14,5 per cent in Australia, 11,4 per cent in the USA, and 3,4 per cent in Japan.

It is therefore clear that measures will have to be taken to address this imbalance if investors are to be attracted to capital-intensive ferroalloy projects. The State's acceptance of the measures in Section 37E of the Income Tax Act of 1962 is a positive development in this respect. Section 37E allows for accelerated capital write-offs on new projects involving mineral beneficiation for the export market.

Production Costs

Trends in future production costs, including transportation costs, suggest changes in the design and location of future ferroalloy plants. Increasing electricity costs with the demise of the power-rebate scheme will favour pre-reduction technology. Large-scale electricity consumers in South Africa are in an enviable position in that they are supplied by a low-cost producer with a well-developed infrastructure and an overcapacity in electricity-generating facilities. Eskom has indicated that it is willing to negotiate favourable long-term power tariffs with large consumers such as ferroalloy plants.

The incorporation of more effective pollution-abatement equipment in the design of future plants has become mandatory in our society, where the protection of the environment enjoys increasing support. The costs of such equipment contribute significantly to the capital costs of new plants, while the retrofitting of existing plants can be even more expensive. The recycling of waste products such as slag and flue dust may present producers with cost-saving opportunities.

Higher transportation costs for ferrous-metal ores resulting from the abolition of rail-tariff cross-subsidization will favour beneficiation prior to export and the location of ferroalloy plants closer to the metal-ore deposits. This follows a general shift in domestic policy from a policy favouring raw-material production and export to one of adding value to locally produced commodities.

Mineral Raw Materials

The availability of large reserves of easily exploitable ferrous metal and coal reserves gives South African ferroalloy producers a comparative advantage on international markets. The question needs to be asked whether the producers, in fact, capitalize on this advantage. The analysis of ferrous-metal trade statistics gives some indication of the level of development of the South African ferroalloy industry[12].

If the percentage of total annual ore sales represented by local sales is calculated, a clear trend in the local consumption of ferrous metals in primarily ferroalloy and steel production can be obtained. Table III and Figure 2 show the local beneficiation ratios of the three ferrous metals saleable in both raw and beneficiated form, i.e. chromium, iron, and manganese. Nickel, silicon, and vanadium are not normally traded as ores and cannot be analysed in the same way.

Up to the 1980s, iron displayed a declining trend in the local beneficiation ratio compared with the increasing local beneficiation of chromium and manganese. Whereas the local iron-ore mining industry was established primarily to sustain the local steel industry, the chromium and manganese mining industries were developed for the export market. It therefore follows that most of the locally mined iron ore was processed into iron and steel mainly by Iscor in 1960, while only 6,8 per cent of the locally mined chromium ore was processed in South Africa during the same year.

TABLE III
LOCAL BENEFICIATION RATIOS OF FERROUS-METAL ORES
(LOCAL SALE MASS AS % OF TOTAL SALE MASS)

Year	Chromium	Iron	Manganese
1960	6,8	87,0	–
1965	20,9	79,3	–
1970	24,4	66,7	–
1975	37,4	74,4	19,7
1976	42,9	74,6	29,0
1977	45,5	41,2	30,5
1978	43,2	41,0	36,0
1979	50,8	38,6	34,9
1980	51,8	45,9	33,7
1981	47,3	45,8	36,4
1982	48,4	47,4	36,2
1983	63,7	54,2	29,8
1984	64,0	44,0	27,6
1985	58,0	51,0	34,3
1986	67,4	54,5	40,0
1987	64,7	55,8	49,7
1988	60,8	50,8	37,1

Source: Von Below, M.A. (1990). p. 235
Note: Bophuthatswana's share of trade is excluded after 1977

The opposing trends in the chromium and manganese industries, on the one hand, and the iron industry, on the other, reflect the different reasons for their establishment.

The South African steel industry, in the form of Iscor, was established by the State mainly for strategic reasons, making South Africa self-sufficient in steel and creating a domestic level of competence in metallurgical know-how. The profit motive was thus not a major factor, evidenced by the reluctance of local entrepreneurs and larger mining companies to establish large-scale steel mills after the discovery of the large iron-ore deposits at Sishen and Thabazimbi.

The profitable international market for chromium and manganese ore, however, encouraged private companies to exploit such ore deposits soon after their discovery. While making profits by exporting ores, these companies had little incentive to engage in complicated pyrometallurgical beneficiation processes. As their knowledge of the market and the required technology expanded, these companies recognized the market opportunities for ferroalloys, and expanded their operations into the smelting of chromium and manganese ores.

Figure 2 clearly indicates the trends mentioned and also suggests a flattening out of local beneficiation ratios for iron and manganese at about 50 per cent for iron and just below 40 per cent for manganese. Even though South Africa has the iron-ore exporting infrastructure in the Sishen–Saldanha scheme to further penetrate the international iron-ore market, intense competition from countries such as Brazil and Australia will ensure that iron's local beneficiation ratio will not decline much below 50 per cent. The local beneficiation of manganese could,

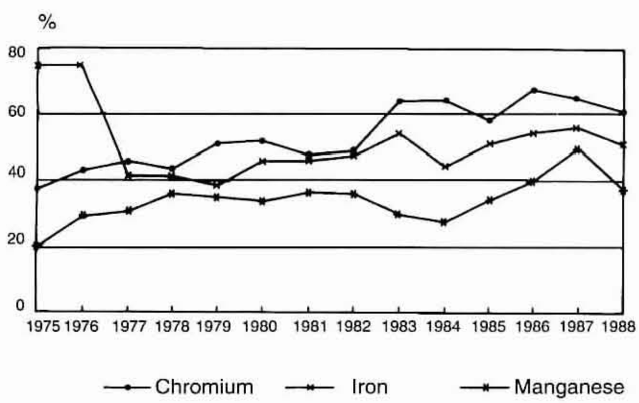

FIGURE 2. Local beneficiation ratios
(Source: Table III)

however, increase towards 50 per cent if new beneficiation opportunities, such as the market acceptance of manganese-based stainless steels and new manganese chemicals, are realized.

The beneficiation of chromium is still experiencing a growth phase in the South African industry, and could level off to the processing prior to export of around 80 per cent of all locally mined chromium ore. The recent expansions in ferrochromium capacity by South African producers and the establishment of new facilities such as Batlhako, Chromecorp Technology, and CMI Rustenburg (Purity) are indicative of this trend.

The economic virtues of a diversified export market should be kept in mind in any consideration of the level of local beneficiation for ferrous-metal ores. To some, the efforts towards 100 per cent local beneficiation of domestically mined raw materials represent optimality, but a level of beneficiation dictated by the free market will satisfy the prerequisites of optimality. If it seems economically feasible to export 20 per cent of locally mined chromium ore without any beneficiation, the absence of restrictions on such trade will result in a Pareto-optimal chromium trade for this country. A diversified export trade operating in the markets for both raw and beneficiated commodities is also less vulnerable to any severe fluctuations in one particular market.

However, the presence of substantial ferrous-metal deposits does not automatically lead to the conclusion that local beneficiation activities would be economically feasible. Production-cost elements other than those for metal ores and coal, such as those for capital and skilled manpower, may prove to be significant determinants of the feasibility of beneficiation projects. Vertical integration of ferrous-metal mining and beneficiation activities could provide South African companies with a larger flexibility in cost controls, and assure them of supply security. These factors may prove to be valuable in the future ferroalloy market of the world.

Industry Structure

The vertically integrated structure of South Africa's ferrous-metal beneficiation industry favours companies currently producing ferroalloys to engage in future expansions of beneficiation capacity. Furthermore, the capital intensity and large economies of scale of ferroalloy plants favour firms with the financial backing of larger institutions such as the mining houses. The takeover of Batlhako by Samancor and Purity by CMI supports the contention that the larger firms have an advantageous position in the production of ferroalloys.

Local producers have to maintain a competitive *capacity*, i.e. the ability to compete, owing to the availability of technical know-how and physical infrastructure, in their efforts towards international competitiveness[13]. Again, those companies well established in ferroalloy production have an advantage over new entrants on the basis of competitive capacity.

Manpower and Technology

Inadequate local manpower and technological infrastructure will severely impair future developments in the South African ferroalloy industry. The lack of skilled manpower and the dearth of resources allocated to research and development of innovative metallurgical technology have a constraining effect on new ferrous-metal beneficiation projects. International trade theory and historical example, such as the impetus given to the local ferrochromium industry by the development of AOD technology, emphasize the importance of technological development.

The State's role in the education and training of adequate manpower and the allocation of more resources to research and development should be more pronounced in future. A constructive role in this respect would be more beneficial to the ferroalloy industry than *ad hoc* export incentives merely representing the re-allocation of resources in the local economy.

Analysis

After the first planning stage of a project, when the strategic factors have been identified and put into a strategic-planning framework, the assumptions behind these factors should be analysed and a financial valuation of the project made.

The first can be achieved by the gathering of analysed data from experts in the industry[14]. In this study, a questionnaire was sent out to selected individuals requesting their considered opinion on the relative importance of the strategic factors identified in this paper.

Relative Importance of Strategic Factors

An analysis of the relative importance of the factors determining the economic feasibility of future ferrous-metal beneficiation projects may prove to be crucial in the selection and location of projects. By knowing which factors are considered to be more important in the determination of project feasibility, entrepreneurs can allocate priority attention to them when contemplating new ventures.

Table IV depicts the results of a survey among the production and marketing management of the South African ferrous-metal beneficiation industry. According to this survey, the most important consideration in the planning of new projects is the projected market conditions for the saleable product, with a 23 per cent weighting. The availability of domestic metal-ore and low-cost energy supplies is ranked next, with a 15 and 14 per cent weighting respectively. Following these factors are the exchange-rate projections, at 10 per cent weighting, and the availability and cost of capital, at 8 per cent. The remaining factors are perceived to be of lesser importance, receiving evaluations with a weighting of between 1 and 7 per cent.

Financial Valuation

ferroalloy projects can be evaluated by use of several analytical methods. Conventional approaches include various derivatives of the discounted cash flow (DCF) analysis, which assumes that a project's value is determined by the present value of the project's incremental cash flows discounted at an appropriate cost of capital. The *pro forma* cash flows are then subjected to risk analyses such as a sensitivity analysis and the Monte Carlo simulation.

A sensitivity analysis investigates the effect of changes in crucial variables on the net present value (NPV) and internal rate of return (IRR). The Monte Carlo simulation considers changes on all variables simultaneously, based on specified probability distributions for those variables. The probability distribution of the variable is then sampled randomly, and the samples are combined according to the cash-flow structure. After several sets of samples have been computed (say 500 to 1000 iterations), stable probability distributions of annual cash flows are simulated.

The DCF methods, however, break down when applied to cyclical projects subject to active management, as in the case of ferroalloys[15]. The flexibility of managerial response to external developments, such as price fluctuations, is not considered adequately in the DCF methodology. For long-term ferroalloy projects, management rarely stays within the operating plans assumed for the feasibility study. Managers may modify their capacity in response to price fluctuations, or may implement alternative technology as it becomes available.

In contrast to traditional DCF methods, options-based techniques of project valuation or contingent claims analysis (CCA) take managerial flexibility into account. CCA is based on the principle of traded options, which gives management the right, but not the obligation, to engage in future transactions. However, this approach of project valuation is not yet sufficiently developed to provide a practical substitute for the DCF analysis.

The cost structure of a typical South African ferrochromium plant (Table V) shows the relative importance of cost variables. It clearly indicates that the financial feasibility of ferrochromium projects will be particularly sensitive to the costs of electricity, transportation, ore, and carbon material.

The expert survey and cost analysis used in the evaluation of the strategic factors determining the economic feasibility of ferrous-metal projects show a significant correlation of results. The questionnaire indicated that market opportunities (weighting index 23) and exchange rates (weighting index 10) are considered by experts in the industry to be very important to the economic feasibility of projects. A strong demand for the product and a favourable exchange rate will result in relatively high rand prices for local producers. From DCF sensitivity analyses conducted by the author, variations in product prices were shown to be the major determinant of a project's feasibility[16].

The survey among experts in the industry indicated that the costs of raw materials (weighting index 15) and energy (weighting index 14) deserve close scrutiny in the planning of future ferrous-metal projects. The production costs in Table V indicate that these variables are important in the determination of a project's feasibility.

Conclusion

The contention that South Africa's ferroalloy industry can be expanded in future is supported by both theoretical and practical considerations. Taken that future market opportunities represent the major determinant of the feasibility of a beneficiation project, the international trend towards durable consumer commodities and lifecycle costing for capital projects impacts positively on future expansions of corrosion-resistant steels that utilize chromium, nickel, and, to a lesser extent, manganese. It is believed that the increasing concern for the environment will result in an increased demand for materials suitable for recycling, such as stainless steels, and an ever-increasing rejection of materials perceived to pollute the environment, such as plastic consumer articles.

In the ferroalloy industry in particular, there is scope for the pre-reduction and sintering of ferrous-metal ores. Samancor's manganese-ore sintering plant near Hotazel has proved to be a successful expansion in this sector's beneficiation industry. The resultant increase in

TABLE IV

FACTORS DETERMINING THE FEASIBILITY OF FUTURE FERROUS-METAL BENEFICIATION FACILITIES

Factor	Percentage weighting					
	1	2	3	4	5	Av
Market opportunities for the saleable product	10	25	20	30	30	23
Local metal-ore deposits	25	5	20	10	15	15
Energy costs and energy availability	25	20	10	5	10	14
Exchange-rate projections	5	15	10	10	10	10
Capital costs and capital availability	10	10	5	5	10	8
Escalation in other production and transport costs	10	5	5	10	5	7
State export incentives	5	10	5	5	5	6
Skilled-manpower availability	5	5	5	10	5	6
Technological innovation and its availability	5	5	5	10	5	6
Domestic consumption of the final product	0	0	10	5	5	4
Other factors (taxation, labour relations, etc.)	0	0	5	0	0	1
Total	100	100	100	100	100	100

Note: A random sample of five ferroalloy production and marketing manager's opinions was used in this analysis, and the average of their percentage weighting was taken to be representative of the South African ferrous-metal beneficiation industry.

Source: Von Below, M.A. (1990). p. 294

TABLE V
PRODUCTION COSTS FOR A SOUTH AFRICAN FERROCHROMIUM PLANT IN 1991

Cost component	US$/t
Electricity (4390 kWh per tonne)	135
Transport (plant to market)	122
Ore	75
Carbon materials	58
Labour	36
Fluxes, electrodes, etc.	16
Working capital	10
Other direct costs	97

Note: Costs are expressed in 1991 US dollars per tonne of charge chromium produced
Source: Confidential industry sources and author's estimates

ferromanganese-smelting efficiency by use of the sinter product created a substantial international demand for the product. A similar increased smelting efficiency, achieved through the pre-reduction of chromium and iron ores, has established such beneficiation practices for future expansions.

An exciting opportunity for the expansion of beneficiation may lie in the production of fabrication alloys through the promotion and large-scale production of manganese-containing stainless steels[17]. The excellent corrosion-resistant, high-strength, and low-cost properties of these steels will act in favour of market development and the creation of international demand to warrant the establishment of large-scale mills for their production. The local beneficiation of South Africa's chromium, iron, manganese, and nickel resources will be substantially enhanced by the creation of an industry producing manganese-containing stainless steel.

The question of what needs to be done to facilitate new ferroalloy ventures can best be answered by an analysis of the State's role in the promotion of local beneficiation. An evaluation of the State's export incentives and exchange-rate policy, for example, has indicated that past policies had little effect in creating an environment conducive to the establishment of new private-industry projects on the beneficiation of ferrous metals, with the possible exception of the rebate on electrical power that was applicable in some instances[18]. The promotion of manpower development and technological research and development will prove to be more beneficial to future industrial growth than the *ad hoc* incentives propagated so far. The creation of a more stable socio-economic environment will have a positive impact on the future availability of capital for new projects, and will open up markets for beneficiated products that are currently subject to economic sanctions. Furthermore, the South African monetary authorities and politicians should be made aware of the importance of exchange-rate stability for long-term planning.

The analysis of ferroalloy production costs suggests a number of policy considerations for South African managers. Innovation in technology, product range, and marketing will play a major role in keeping the industry competitive in a dynamic international market. Escalations in the cost of electricity will make pre-reduction more economic, while pollution-abatement technology will have to be improved if it is to be more effective and cheaper. Escalations in transportation costs dictate that ferroalloy plants (first-stage beneficiation) should be located closer to the metal-ore mines. However, plants that are fabricating alloys should be at consuming centres, as dictated by the concept of market-area locational interdependence.

The ten strategic factors identified in this environmental study indicate that South Africa finds itself in a competitive position to expand its ferroalloy production capacity in future. In addressing these strategic factors scientifically, the South African ferroalloy industry will ensure its continued economic feasibility.

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