

RESOURCE-BASED SUSTAINABLE DEVELOPMENT: AN ALTERNATIVE APPROACH TO INDUSTRIALISATION IN SOUTH AFRICA

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ABSTRACT

This paper explores the possibility of a resource-based approach to industrialisation in South Africa. While mineral endowments are generally regarded as a “curse” for long-term growth, the experiences of highly-industrialised economies such as Sweden, Finland and the United States suggest that promoting clusters of ‘sidestream’ and ‘downstream’ activities can assist in achieving national development goals in terms of economic diversification and increasing the well-being of the population. Given the high-tech nature of mining- and minerals-processing activities, such a sector offers numerous possibilities for catalysing sustainable development and facilitating South Africa’s gradual transition to a knowledge-based economy.

Introduction

Despite the remarkable progress that has been made in trade reform, it is a matter of controversy as to whether the current approach to industrialisation in South Africa will generate the required levels of growth, competitiveness and employment to break the country’s poverty and unemployment cycle. The national economic debate has moved from macroeconomic management strategies to job creation, skills development, attracting foreign direct investment and building internationally competitive industries (CDE, 1998a; 1998b; Chang, 1998; Altman, 2001; *Engineering News*, 2001d; DTI, 2002). However, an old and central concern has re-emerged. South Africa is a resource-based economy with an extraordinary endowment of mineral resources. Indeed, the minerals sector accounts for approximately 8% of GDP and close to half the country’s exports (Minerals Bureau, 2001). The concern is that continued specialisation in natural resources, particularly minerals, will leave South Africa behind in the slower “old” economy. It is argued that natural resources, especially minerals, are a ‘wasting asset’; suffering long-term price decline, having volatile prices, and being environmentally unfriendly and thus cannot meaningfully contribute to development (Auty, 1995; Davis, 1995; Gylfason, 1999; *Engineering News*, 2000a; ECA, 2001). Arguments, however, fail to recognise that a number of developed countries (United States, Canada, the Nordic countries, and lately Australia) have enjoyed economic success despite a reliance on such an unfashionable sector as minerals. Key to the success of these countries’ industrial development was the utilisation of the resource base as a platform for achieving economic diversification. The further processing of natural resources together with the development and support of a capital goods and service sector directly linked to the resource base played a pivotal role in ensuring that the benefits of

the natural resource endowment continued long after their depletion (Porter, 1990; Vuori and Ylä-Anttila, 1992; Pajarinen *et al.*, 1998; Karppi, 2001; Wright, 2001).

This experience presents South Africa with an alternative approach to future economic growth and industrial development planning in the country. It posits a central role to the underlying domestic (minerals) resource base for generating competency and competitiveness in complex manufactures and the fostering of economic ‘linkages’ and presents three alternatives for maximising the economic potential and ensuring the sustainability of the country’s mineral endowment. Firstly, through the development of linkages ‘upstream’ and ‘downstream’ of the resource-based plant. Secondly, through the development of capital goods and service sector initially supporting and dependent on the resource-based sector, but eventually emerging into an independent sector (and generator of economic wealth) in its own right. Lastly, the migration of generic technologies from a developed capital goods and service sector to other high-tech industrial sectors – the ‘lateral migration’ of technology.

In this paper the idea of a ‘resource-based sustainable development’ strategy for South Africa will be explored. The paper will commence with a brief review of industrial strategising in South Africa to-date and will identify some of the key challenges facing industrial development planners and policy makers, particularly in light of the current global economic context of creativity, knowledge and innovation. The reasons why the minerals sector should be the focus of industrial development as well as the various options for maximising its inherent economic potential will be presented. Evidence of cluster development and linkage creation within the South Africa mining and mineral processing industry will also be highlighted. In discussing the potential for the successful implementation of a resource-based industrialisation strategy in South Africa, some of the key lessons from the experiences of industrialised countries such as Sweden, Finland and the United States will be presented and related to the South African scenario.

South Africa: the current economic situation

There is general agreement that a rich endowment of natural resources, particularly in minerals, has played a critical role in the evolution of the South African economy. Indeed, it was the discovery of diamonds and gold in the late nineteenth century and their location in an undeveloped interior and relative inaccessibility which provided the initial impetus for industrialisation. The need for heavy equipment, power supplies and large forces of organised labour to extract and process underground ore

deposits triggered a series of spin-off activities in a diverse range of goods and services in sectors such as transport (rail system), power generation (coal mining), manufacturing, and commercial farming (Abedian and Standish, 1992; Davis, 1994; Fine and Rustomjee, 1996; Mainhardi, 1997). Despite this beneficial legacy and the opportunities it provided for catalysing rapid growth and development, overall economic growth and industrial diversification was held back by direct state involvement in the economy and the dominance of import substitution policies between the early 1920s and early 1990s (Davis, 1994; Fine and Rustomjee, 1996; Chang, 1998).

By the early 1990s it was apparent that South Africa had reached an economic impasse. The prevailing system of import substitution industrialisation (ISI), which was designed to support and uphold the Nationalist government's desire of political and strategic self-sufficiency, not only failed to create a dynamic manufacturing goods sector and generate sufficient employment opportunities to make a meaningful impact on unemployment, but it also resulted in a distorted spatial landscape in South Africa with developed White industrial centres juxtaposed with undeveloped Black homelands on the periphery (Archer, 1987; Black and Stanwix, 1987; Abedian and Standish, 1992; Davis, 1994; Fine and Rustomjee, 1996; Chang, 1998). In addition to this, lack of access to technology and capital; control over education; a low level of commitment by industries to human resource development, research and development (R&D), and the promotion of best-practice; poor supply chain relationships; and, excessively high input costs, created a poor skills base and low level of entrepreneurship (Hirsch and Hanival, 1998). Kaplinsky and Mhlongo (1997, 57) sum up some of the impacts of South Africa's previous approach to industrialisation in the words, "The post-Apartheid legacy includes a sustained period of falling per capita incomes, stagnation of manufacturing output, high levels of unemployment, a highly segmented profile of consumers, a particularly unevenly stratified skill distribution amongst its labour force pattern of industrial relations which reflect the tensions of the Apartheid era". In contrast to South Africa, during the same period a number of newly industrialised countries (NICs) (Korea, Singapore, Taiwan and Hong Kong) succeeded in achieving high growth and more favourable distributive impacts by pursuing an export-oriented, diversified growth strategy (Porter, 1990; Vogel, 1991; Lawrence, 1993; Leipziger, 1993). These facts not only called into question the prevailing development strategy, but since 1994 have resulted in a shift from a strongly interventionist development policy focused on domestic markets to an outward oriented strategy.

In particular, it was realised that in order create an investment climate conducive to attracting foreign capital, the goals and objectives of economic growth and development at the international,

national, regional and local level and the strategies and policies necessary to achieve them needed to be reassessed. Five core issues were identified. First, due the fact that ISI insulated domestic firms from external competition and access to foreign markets, the level of industrial competitiveness, management practices, innovation and international marketing tended to be low. State enterprises, therefore, needed to be restructured along global competitive lines. Second, there needed to be a gradual phasing out of tariffs, protectionism and price controls. Third, the fiscal deficit needed to be reduced. Fourth, trade and investment flows in southern Africa had to increase. In addition, in becoming an outward-oriented economy, integration into international supply networks was highlighted as being important primarily because integration stimulates the formation of clusters either vertically (along the beneficiation chain) or horizontally (complementary goods and services) with concomitant value-added and employment benefits. Fifth, since exports had historically been focused on primary resource products, increasing and diversifying exports beyond this stage was considered essential (Department of Finance, 1996; Arkwright *et al.*, 1998; CDE 1998a). In order to overcome these challenges the Government adopted a new macroeconomic policy framework in 1996 entitled the Growth, Employment and Redistribution (GEAR) strategy. The GEAR strategy places considerable emphasis on achieving increased economic growth, fostering expanded employment opportunities, and overcoming many of the legacies of apartheid through redistribution (Department of Finance, 1996). A revision and reformulation of other economic growth and industrial strategies accompanied the implementation of the GEAR strategy (Department of Finance, 1996; Arkwright *et al.*, 1998; CDE, 1998a).

While this more externally focused and value-adding strategic approach to economic transformation, growth and development in South Africa has stimulated exports and encouraged increased international trade and investment, formulating an appropriate economic strategy that leads to sustained economic and employment growth remains a key development challenge (Department of Finance, 1996; CDE, 1998a; 1998b; Hirsch and Hanival, 1998; Altman, 2001; *Engineering News*, 2001d; DTI, 2002). Although the country's GDP grew by between 1.7 and 3.4 per cent in the first three years following 1994, as compared to the annual growth rate of East Asian countries such as China, Malaysia and Korea (7-13 per cent) this was particularly low. It has been asserted that in order to match Taiwan's current annual growth rate of 12-13 per cent, South Africa, with a population growth rate of 2.5 per cent, would need to increase its growth rate to 7-8 per cent per year (Hirsch and Hanival, 1998). In terms of growth potential, according to the Global Competitiveness Report 2000, South Africa is only ranked thirty-third out of fifty-nine countries surveyed on its growth competitiveness ranking (*Engineering News*, 2000b). With regard to the employment challenge, it has been pointed out that in order to ensure

that the current level of unemployment (30 per cent in the formal sector) does not increase, more than 250 000 new jobs have to be created. A further 100 000 new jobs need to be created annually to absorb new entrants into the labour market (Department of Finance, 1996; CDE, 1998b). In order to achieve a significant decrease in unemployment, Archer (1987) asserts that the growth rate of GDP must exceed productivity growth. In order to resolve this crisis and fulfil the broader national development challenges, it is essential that each strategy undertaken by the government to foster growth generates balanced and sustainable, economy-wide impacts and maximises the use of available resources.

It is the responsibility of the national Department of Trade and Industry (DTI) to ensure that the broad economic and development challenges in terms of industrial restructuring, export and investment facilitation, employment creation, and privatisation are achieved (Hirsch and Hanival, 1998). The most recent approach by the DTI to gradually fulfil these objectives and complement macroeconomic strategies is the proposed 'Integrated Manufacturing Strategy'. Although still in the initial phases of formulation, the new strategy will deal with three key issues. First, investment and support of all stages of potential productive enterprises, with particular emphasis being placed on industries engaged in the beneficiation of the country's diverse range of natural resources. The Minister of Trade and Industry, Alec Erwin, asserts that "We have to bring into the economy sectors of production that have not been there before. That requires systematic support for the processing of products, ensuring that the logistics are good, that infrastructure is good, and that we have technological and other support necessary for the processes of beneficiation" (*Engineering News*, 2000c, 7). Second, integration of the manufacturing sector with the business services associated with the 'New Economy' (high-tech industries particularly those associated with the information and technology sectors). The third issue to be targeted under the new strategy is the stimulation of regional production systems within the southern Africa region, beginning first with raw material products but later evolving into assembly and manufacturing activities, and greater export orientation (*Engineering News*, 2000c; 2000d; DTI, 2002).

It is apparent from a review of economic and industrial planning since 1994, that in becoming a more liberalised economy considerable emphasis has been placed on those sectors and industries in which South Africa has a comparative advantage, particularly those engaged in the processing of mineral resources and energy.

South Africa's mineral and energy comparative advantage

South Africa can be broadly defined as a minerals economy (Nankani, 1979; Jourdan, 1992; 1994). Indeed, the mining and metallurgical sector accounts for almost 8 per cent of GDP and close to half of the country's exports (Minerals Bureau, 2001). Not only does the country possess a considerable portion of the world's reserves of alumino-silicates, chromium, gold, manganese, platinum-group metals, vanadium and vermiculite, but it is also rich in antimony, fluorspar, phosphate rock, titanium and zirconium. This exceptionally large minerals base has enabled South Africa to play an important global role in terms of the production and export of many primary minerals and some processed mineral products for a considerable length of time (Jourdan, 1994; Chamber of Mines, 2000; Minerals Bureau, 2001). Not only has the minerals sector contributed significantly to the country's GNP, providing capital for reinvestments and new developments, but it has also provided the impetus for the development of a diverse secondary industrial sector as well as an extensive and efficient physical infrastructure (Davis, 1994; Chamber of Mines, 2000; Menell, 2000). It also raises the tone of the regional economy by its strong developmental impact in the SADC countries.

In 1999, mining contributed approximately R47.1 billion (6.5 per cent) to the gross domestic product with an additional estimated 14 per cent through associated multiplier effects. While sales of primary mineral products accounted for 33.5 per cent of total export revenue, with the inclusion of various processed mineral products such as ferroalloys, aluminium, carbon and stainless steels, this contribution increases to over 40 per cent (Minerals Bureau, 2001). Since South Africa is rich in minerals and energy, industries involved in the processing and beneficiation of these resources have featured prominently and continue to form the basis of the country's industrial and economic growth strategies (Davis, 1994; Jourdan, 1994; Minerals Bureau, 2001).

Despite the dominant and significant role of mineral-related activities in South Africa, particularly since the 1970s, it has been argued that there has been an historical wasting of resources. Davis (1994) asserts that the economy was built on a minerals industry that consumed rather than produced foreign exchange and which came to be characterised large-scale, capital-intensive, resource-based upstream activities (Chang, 1998). According to Fine and Rustomjee (1996, 14) an emphasis on mineral and energy related activities "effectively led to policies which supported its core sectors and precluded the adoption of other industrial policies of diversification away from economic dependence on South Africa's resource base". It has been pointed out that given the continuing gold crisis in the country

and the fact that most high grade or shallow reserves are close to depletion, an alternative source of exports is required if sustained and long-term growth and development is to occur (Jourdan, 1994; Chamber of Mines, 2000; Minerals Bureau, 2001; DTI, 2002). Furthermore, Arkwright *et al.* (1998) maintain that a current impediment to enhance national and regional trade, both in South Africa and the SADC region, is the lack of an adequately diversified industrial base.

A number of fundamental changes are taking place at the global level which are reinforcing the national imperative to diversify domestic exports (*Engineering News*, 2000a; ECA, 2001; DTI, 2002). Increasingly, created assets such as technology and innovation capacities, the availability of skilled human capital, and marketing networks are replacing traditional price-driven sources of national comparative advantage (such as raw materials, capital and cheap labour). The main impetus behind this shift in emphasis to competitive advantages has been the revolution in information and communication technology (ICT) (Pajarinen *et al.*, 1998; DTI, 2002). Countries dependent on traditional endowments for continued growth and development are facing increased competition in four areas. First, the ICT revolution has assisted in reducing many of the geographical barriers and transport costs associated with the export of raw materials. Raw materials are increasingly being traded internationally which has meant that manufacturers throughout the world are faced with similar prices and delivery conditions for raw material inputs. Competition has also been intensified as a consequence of historically low material commodity prices. ICT has also contributed to consolidation in resource-based industries by creating new economies of scope. Changing social and environmental perceptions, especially in the mining and minerals sector, have broadened the range of knowledge that is relevant to economic success, adding a new dimension to securing competitive advantage in the industry (Pajarinen *et al.*, 1998; Menell, 2000; DTI, 2002).

Second, the diffusion of information and production knowledge has increased. Wider access to information and easier means of communication have enhanced the efficiency of markets and enabled capital and skills to flow to where they can be employed most productively. It has been pointed out that as the market for new technology has increased, a concomitant increase in the need for the continual adaptation and innovation in order to remain competitive has also occurred. A skilled and adaptive workforce and effective management capacity are increasingly regarded as being prerequisites for sustained and long-term economic growth. The shift by multinational companies to basing their locational decisions on the availability of such competitive advantages has meant that countries lacking traditional comparative advantages are equally placed to compete for foreign direct investment (FDI).

The need to identify new sources of competitiveness has therefore become a necessity (Pajarinen *et al.*, 1998; Humphreys, 2000; DTI, 2002).

Third, over the past two decades the majority of countries throughout the world have introduced measures promoting macroeconomic stability while simultaneously opening markets to competition through liberalisation and privatisation. As large industrialising countries such as Indonesia, India, Brazil and China increasingly integrate into the world economic system, cheap, unskilled and semi-skilled labour is increasingly becoming an unsustainable source of comparative advantage (Pajarinen *et al.*, 1998; ECA, 2000; DTI, 2002).

While it has been recognised that South Africa cannot ignore its basic comparative advantages in terms of its mineral resource endowments, in light of current international and national trends, the limitations of a too exclusive reliance on the simple export of unprocessed and semi-beneficiated resources are also acknowledged. Indeed, it has been pointed out that “a reliance solely on past bases for competitiveness, such as abundant natural resources and cheap unskilled labour, will create an increasingly low-value economy, unable to address our socio-economic legacy of inequality” (DTI, 2002, 3). Furthermore, in an increasingly globalised and networked world Humphreys (2000, 1) notes that what has become more and more apparent is that “it is not simply about pushing back the frontiers of knowledge; it is also about the more effective use and exploitation of all types of knowledge in all manner of economic activity”. While it has been asserted that “In a world of mobile factors of production, the scope of policies has narrowed” (Pajarinen *et al.*, 1998, 12) and that each country is unique in terms of its historical development and therefore should “not just ‘buy into’ one particular [economic] model – they must develop their own, which meets their requirements” (*Engineering News*, 1999, 9) valuable insight and lessons can nevertheless be drawn from a review of the experiences of countries which have faced similar development challenges to those currently experienced by South Africa. Indeed, Chang (1998, 59) states that “One simple, but very useful, way of clarifying and making less abstract, the vision that should guide South Africa’s future industrial policy is to identify certain advanced countries with most *prima facie* similarities and check whether South Africa can use them as ‘models’ for its developmental strategy”. As South Africa’s comparative advantage rests in mineral resources, exploring the experiences of other mineral-rich economies is therefore necessary.

Mineral-based industrialisation: the international experience

The potential for natural resources, and in particular minerals, to contribute to accelerated gross domestic product growth, healthy structural change, and regional development has been a widely contested issue in development literature for a considerable length of time. Mineral resources are often regarded as being a paradox for development. On the one hand, they are seen as a ‘curse’ (Altamirano, 1999; Östensson and Uwizeye-Mapendano, 2000; ECA, 2001; Gylfason, 2001; Wright, 2001). The economist Adam Smith noted as early as 1776 that, “Projects of mining, instead of replacing the capital employed in them, together with the ordinary profits of stock, commonly absorb both capital and stock. They are the projects, therefore, to which all others a prudent law-giver, who desired to increase the capital of his nation, would least choose to give any extraordinary encouragement...” (cited in Wright, 2001, 1). The diverse experiences of mineral- and petroleum-rich countries in Africa and Latin America which benefited from the oil and mineral booms in the late 1970s and early 1980s seemed to validate this assertion. Instead of catalysing economic diversification, increasing the value added of exports, and enhancing employment- and income-generating opportunities at the local level, what often resulted was a discrepancy between official expectations regarding resource-based projects and the subsequent results (Roemer, 1979; Auty, 1989; 1991; 1995; Davis, 1995). Moreover, research conducted by UNCTAD and the Harvard Institute of International Development comparing the experiences of these countries with the resource-poor, but economically successful, Asian ‘tigers’, provided strong statistical evidence for an inverse relationship between extensive mineral endowments and strong GDP growth (Östensson and Uwizeye-Mapendano, 2000; Gylfason, 2001; Wright, 2001). Auty sums up the results of the various econometric studies in the words “...the mineral economies tend to have a more skewed income distribution than their non-mineral counterparts. They also have had limited success in their efforts to secure an equitable regional distribution of mineral benefits” (1991, 73).

On the other hand, Wright (2001) maintains that “one should avoid jumping to the conclusion that natural resource assets constitute ‘negative assets’ for the development of a country”. Similarly, Roemer (1979, 165) argues that “although resource-based industrialisation would perpetuate the pattern of dualism and inequality present in a typically, resource-rich country, it might not result in a substantially worse interpersonal distribution than any other industrialisation strategy”. There are a number of countries whose economies have performed successfully in recent decades despite a reliance on an unfashionable sector such as minerals. Most notably, in Sweden, Finland and the United States the natural resource sector evolved from a position of low-technology based on low-cost labour to one

characterised by highly-skilled, knowledge-intensive and export-oriented activities. Such a growth strategy was based not so much on the continued exploitation of a rich natural resource base as increasing the domestic value added associated with such natural resources by prompting the development of those activities which naturally tend to ‘cluster’ around resource-based processing and extraction industries. These included industries supplying critical ‘sidestream’ inputs (such as capital equipment, consulting services, consumables), and activities engaged in the further processing or utilisation of the outputs (‘downstream’ industries). Clustering not only enhanced the productivity of the workforce, but also resulted in increased income distribution in the local population and rapid economic growth. More significantly, it prompted a shift to a more dynamic and sustainable growth trajectory (Porter, 1990; Vuori and Ylä-Anttila, 1992; Vuori, 1997; Pajarinen *et al.*, 1998; Karppi, 2001; *Mining Weekly*, 2001c; Wright, 2001).

The developed country experience of resource-based industrialisation ties in with many issues drawn from the literature on industrial and local economic development. In particular, by the mid-1980s, declines in commodity prices together with debt repayment pressures forced many countries to re-evaluate their domestic economic and industrial policies. Not only did many economies abandon domestically focused industrial strategies in favour of more outward-oriented ones, but a reliance on natural resource-based production became increasingly replaced with technology-based and labour-intensive exports (Archer, 1987; Ballance, 1987; Porter, 1990; Lawrence, 1993). As such, key features in the resource-based industrialisation experience in many industrialised countries, in terms of cluster development, industrial districts and changing patterns of economic development and competitive industrial strategies, parallels the experience of many resource-poor, newly industrialising countries such as South Korea, Singapore and Taiwan (Ballance, 1987; Porter, 1990).

According to Porter (1990, 562), there are three distinct phases through which nations have to progress in order to achieve economic prosperity. In the first phase, economic growth is initiated by and limited to the development of industries associated with identified factor endowments (capital, labour, natural resources). Despite the fact that virtually all countries begin their industrialisation process at this state, Porter (1990) asserts that few countries ever move beyond it.

In the second phase, repeated investment and upgrading in these initial competitive industries stimulates the emergence of ‘clusters’ of similar and associated industries. Each cluster assists in broadening the individual base of the economy. In this stage, commitment on the part of the government

and firms to improving factor advantages as well as firm strategy, structure and rivalry are key to increasing and maintaining the initial competitive advantage. Porter (1990, 278) asserts that while some countries have been able, to upgrade with relative success (Japan, South Korea, Taiwan, Singapore, Hong Kong, Spain, and to a lesser extent, Brazil) others have been unable to sustain this stage of development.

In the third phase, continual innovation and human resource development within firms and commitment by the government ensures that growth is sustained and the competitiveness of the original resource-base is maintained and embedded in other sectors throughout the economy. A central feature of this stage of development is a gradual reduction in the dependence of the economy on the initial factor endowments for competitive advantage (Porter, 1990). Instead, appropriation and improvement of technology and methods previously imported and the creation of new strategies is of greater importance. According to Porter (1990), increased consumer demand for sophisticated products, rising personal incomes, higher levels of education, and increased levels of competition among local industries characterise countries at this stage of development. Germany, Sweden, Britain, the United States, Japan and Finland are countries that have succeeded in achieving this stage of development.

Although a number of nations with considerable natural resource endowments have been able to enjoy high per capita income levels despite a reliance on resource endowments (Kuwait, Saudi Arabia, Australia and Canada), the unsustainable nature of such an approach is also recognised. Consequently, many resource-rich countries have been forced to seek alternative routes to industrialisation. According to Sengenberger (1993, 318), what has also become apparent in the experiences of various industrialised countries is that the effectiveness with which resources are deployed and maximised is often of greater importance than the actual availability of such resources. Likewise, Porter (1990, 15) states that “it is where and how effectively factors are deployed that proves more decisive than the factors themselves in determining international success”. In this regard, an examination of the experiences of three developed countries, which successfully used their resource-base as a catalyst for further economic growth and development, and offer potential lessons for South Africa, is necessary.

Finland

Underpinning Finland’s transition from a poor, predominantly resource-based economy, to a highly industrialised and competitive state, has been the successful management and exploitation of a rich, albeit narrow, endowment of natural resources. Although rich in select minerals and hydroelectric power resources, it was around forestry-related activities that industrialisation and subsequent

diversification commenced. The importance of forestry in the historical development of the country is pointed out by Vuori and Ylä-Anttila (1992, 1) in the words, “the forest sector forms by far the most important development block in the Finnish economy”. Similarly, Herring (2001, 11) asserts that “Ever since the industrial revolution finally made its way to Finland, the country’s forests have been one of the mainstays of the economy”. Forest-related products, mainly sawn wood and pulp, accounted for approximately 90 per cent of Finnish exports until the 1920s. Although the contribution of primary production in total production has decreased significantly over the years (49 per cent in 1900 to 10 per cent in 1980), the forestry sector nevertheless still plays an integral role in the Finnish economy. Not only does it comprise a quarter of current exports (making it one of the three basic pillars of the economy after metals and electronics), but in 2000, of the Top 25 companies in Finland 9 were pure forest-cluster based (compared to Canada where only 2 out of the Top 60 are pure forest industry) (Vuori and Ylä-Anttila, 1992; Pajarinen *et al.*, 1998; Häggblom and Vasara, 1999; Saarinen, 2000; Herring, 2001).

Finland only made the transition to industrial production in the late 1940s, largely as a consequence of the significant war reparations the country owed the former Soviet Union. In order to meet these payments, a process of diversification was adopted and investments were made in a range of industries, specifically in metals (Vuori and Ylä-Anttila, 1992; Pajarinen *et al.*, 1998; Saarinen, 2000). This phase of investment-driven development culminated in the 1950s and early 1960s, when sectors within investment goods industries developed into important export branches. The total volume of investment goods exported surpassed that of imports for the first time in the mid-1970s (Vuori and Ylä-Anttila, 1992). The gradual shift towards an emphasis in service-related activities over manufactured goods commenced in 1956 and by 1967 comprised as much as 50 per cent of total production (Saarinen, 2000). Faced with a waning resource base in the early 1970s, development planners in Finland were forced to reassess their industrial policies and a more targeted approach to diversification and investment was subsequently embarked upon. Since then, technological change and innovation have played a major role in the economic growth and transformation of the Finnish economy. Although many of the resource-based industries that provided the impetus for initial economic and industrial development still feature, downstream diversification has occurred to the extent that many of the new industries are not even associated with this initial base (Porter, 1990; Vuori and Ylä-Anttila, 1992; Vuori, 1997; Pajarinen *et al.*, 1998; Saarinen, 2000).

More significantly, since the early 1990s, Finland has emerged as one of the world leaders in information and communication technology (ICT). The ICT is the fastest growing industrial cluster in

Finland as well as the most economically significant. It has been pointed out that the role of electrical and electronic industries more than doubled during the 1990s. Indeed, between 1990 and 1998 export growth in this sector increased by an annual rate of approximately 7.4 per cent, making it the third most important pillar in the Finnish economy. Exports of high-technology products exceeded imports for the first time in 1995 and by 1999 accounted for 20 per cent of all Finnish exports. The cellular telephone and telecommunication equipment firm, Nokia, largely dominates high-technology developments in Finland. Between 1995 and 2000, Nokia's value added and exports increased by an average of 33 per cent per year. This has, in turn, boosted the value added of the electro-technical industry as a whole by as much as 27 per cent annually. The fact that Nokia exports contribute to more than a quarter of Finnish exports and 4 per cent of GDP highlights the success of the ITC cluster. In addition to this, GDP has increased by more than 1.5 per cent as a consequence of the Nokia industry. More than three hundred first-order supplier firms support the Nokia cluster and a total of 3 000 firms are indirectly associated with the company. What is perhaps more interesting is the fact that Nokia began as a paper pulp producer in the late nineteenth century and gradually diversified through a series of acquisitions and mergers, product innovations, and divestments into the telecommunications firm it now is (i.e. first into rubber, and then into cables, metal, mining, electrical goods, services and telecommunications) (Rouvinen, 1996; Vuori, 1997; Pajarinen *et al.*, 1998; Ali-Yrkkö *et al.*, 2000; Saarinen, 2000; Ylä-Anttila, 2000).

Central to Finland's industrial success has been a commitment on the part of the government to investment in research and development and nurturing a skilled work force. In the early 1980s, the industrial sector undertook an initiative to improve the level of research and development in Finland as Finnish products were not considered competitive enough in the international arena. Since then investment in R&D has increased steadily. Indeed, Finland currently invests approximately 3 per cent of its GDP in building high-technology capabilities and its research and development intensity is the second highest in the European Union (Vuori and Ylä-Anttila, 1992; Rouvinen, 1996; Pajarinen *et al.*, 1998; Ali-Yrkkö *et al.*, 2000; Ylä-Anttila, 2000).

Sweden

The factors underpinning Sweden's economic and industrial success bear many similarities to those of Finland. In the 1970s, a declining resource base and loss of competitive advantage in resource-based industries (mainly iron ore- and forest-based), due to falling transportation costs and the discovery of new iron-ore deposits elsewhere (Brazil and Australia), prompted a reassessment of the prevailing

approach to economic development (Porter, 1990). Development planners and policy makers adopted a programme of diversification away from resource-based industries into more sophisticated industrial segments and into related and supporting industries such as specialty steels and fine paper, roller bearings, rock drills and fabricated steel products.

According to Porter (1990), the Swedish economy is essentially an economy of related and supporting industries with extensive clustering. A critical factor underpinning Sweden's transition from a natural resource-oriented economy to a high-tech, industrialised state, was the role played by domestic demand. Given the harsh climate, unique geography and specific geological conditions (Swedish rock is one of the hardest in the world), products and services offered by domestic suppliers had to be designed and tailored to deal with these limitations. Porter (1990) points out that Swedish success in transportation and related machinery was connected to the need for transporting ore and timber from far, remote and often inaccessible places. Similarly, success in rock drills, mineral crushing equipment, welding machines, and steel engineering arose as a consequence of stringent conditions associated with the extraction and processing of iron ore and the demands of the ship building industry. Although lacking in coal, power demands from metal as well as paper and pulp processing industries stimulated the development of an efficient high-tension power transmission network using distant supplies of hydroelectricity. Moreover, the lack of coal reserves and the reliance on hydroelectricity for power prompted the development of an electric, as opposed to a steam-based railway system, which in turn triggered a competence in electric motors, first in trains and later in a range of different applications and industrial sectors (Rostow, 1962; Porter, 1990). Many internationally competitive companies in Sweden are currently supporting industries associated with resource-based products (timber, paper products, iron ore mining, iron and steel making and processing). More significantly, many others have emerged through linkages arising from first-order resource-based companies. Notable examples of such companies include Volvo, Saab-Scania, Atlas Copco, SKF, Sandvik, Svedala and Stora-Emso (Porter, 1990; Jourdan, 1994)

Swedish industry has become increasingly knowledge-intensive. In 1999, knowledge-intensive industries accounted for one-third of trade and industry. This positive growth has been followed by a major increase in productivity in knowledge-intensive industries. The telecommunications sector, in particular, is growing rapidly and Sweden is one of the leading countries in the world in the production of telecommunications equipment and with extensive and advanced use of IT among Swedish companies

and individuals. Between 1998 and 1999, teleproducts (led by the ICT company Ericsson) accounted for 80 per cent of the rise in exports (NUTEK, 2000).

Sweden's economic success can also be attributed to a supportive and co-operative government. Not only were public services provided, but considerable investment was made in human resource development and education, particularly engineering. Moreover, there is a firm commitment to long-term and sustained economic diversification and renewal – “Growth depends not just on how many new resources are created but also on what resources are used up. If growth is created by depleting natural resources or by wearing out human labour, the profits of growth are eaten up by their very cost” (NUTEK, 2000). In order to maintain its current level of productivity and innovation, Swedish investments in R&D are the highest in the world relative to GDP. Indeed in 1997, approximately 3.7 per cent of GDP was spent on R&D (NUTEK, 2000). Co-operation and effective information flows between firms within the clusters as well as high levels of domestic rivalry between similar industries have also played a pivotal role. For example, Atlas Copco (mining and construction equipment) and Sandvik (rock drills) co-operated closely for over forty years on marketing and R&D, Volvo and Saab-Scania also competed actively in cars and trucks, and Sandvik and Fagestra in rock drills (Porter, 1990).

United States

An abundant resource base (phosphate, copper, iron ore, coal, oil and natural gas) has underpinned the economic success of the United States. It has been asserted that it is one of the few countries that possesses an extensive range of natural resources and has been able to utilise them to gradually shift into resource-based manufactured goods and more recently, knowledge-intensive industries (Porter, 1990; Wright, 2001). Wright (2001, 2) points out that “The abundance of American mineral resources should not be seen as merely a fortunate natural endowment, but is more appropriately understood as a form of collective learning, a return on large-scale investments in exploration, transportation, geological knowledge, and the technologies of mineral extraction, refining and utilisation”. Indeed, the economic success of the United States can be attributed in part to sizeable and sustained investments in education, research and development, and infrastructure by all levels of government over a considerable length of time. Constant improvement and investment in initial factors of production served to stimulate the expansion and diversification of the initial competitive advantage and thus broadened the economy. Together with strong domestic and international demand conditions, the geographic clustering of firms, the integration of many industries (such as electronics), minimal levels of direct intervention and public ownership of industries, and the government's free and open

trading system and anti-trust policy, the United States has succeeded in becoming world leader in a number of end products, parts, machinery and service industries. Key industrial sectors include, amongst others, automobiles, aircraft, energy, power generation, electronics, mining and construction (Porter, 1990; Wright, 2001).

Lessons from the international experience of RBI

It is apparent from a review of both the developed and developing country experience of resource-based industrialisation, that success was underpinned by a number of unexpected, but high productive, consequences which were stimulated as a result of an initial concentration of investment in resource-based activities. In particular, the emergence of clusters of related and supporting activities through ‘backward’ or through ‘forward’ linkages and knowledge networks. The initial goods and service industries that emerged to support the first resource-based industries in Finland, Sweden and the United States were influenced by a diverse range of endogenous and exogenous factors. Overcoming exogenous factors such as inaccessible mineral resources, harsh climatic conditions, and distance from markets required a gradual and sustained process of improvement, adaptation and innovation. The result was not only a product that had value for a specific industry (capable of enhancing production and generating revenues through commercialisation), but which also embodied value – its development required both the application of a range of skills and creativity as well as an incremental process of ‘learning-by-doing’. The intangible assets created through the product development process provided the opportunity for the application and transfer of the acquired knowledge into similar activities (along the value-added chain) as well as in non-related, but technologically-similar, activities. Through each subsequent phase of product development, knowledge transfer, and industry spin-off, the value added to the original, static resource endowment increased. Moreover, the proximity of firms created spin-offs into other firms and provided the basis for greater interaction and possibilities for knowledge transfer and renewal. Taken together, these factors contributed to increased economic diversification and growth, and assisted in raising the productivity, adaptability and skills of the local work force (Vuori and Ylä-Anttila, 1992; Gylfason, 1999; Ali-Yrkkö *et al.*, 2000; Häggblom and Vasara, 2000).

Second, a culture of commitment and co-operation at the national and local level has emerged with regard to maintaining and enhancing productivity and technological innovation. It has been pointed out variously that a well-educated population, the ability of the scientific and technology organisations to co-operate with each other, co-operative relations between the research community and the business

sector, and the fact that innovation is taken seriously have played an important role in sustaining the ‘virtuous cycle’ of competitive advantage creation (Rostow, 1962; Chamber of Mines, 2000, NUTEK, 2000; Warda, 2001). Moreover, co-operation between the public and the private sectors in the shaping of national science, technology and innovation policy has provided a foundation for a committed and co-ordinated approach to the long-term development of knowledge and skills in these countries (*Engineering News*, 2001b).

The South African minerals sector as a potential ‘engine of growth’

Wright (2001, 1) asserts, “the practical policy issue is whether countries with resource potential should encourage investment, exploration, and research for the purpose of developing that potential to its maximum”. Drawing on the various discussions presented above, in this section consideration will be given to the possibility of adopting a ‘resource-based sustainable development’ route to industrialisation in South Africa linked to the mining and mineral processing sector.

According to Menell (2000), “despite it’s maturity, mining in South Africa is emphatically a sunrise industry”. Moreover, it has been asserted that the contribution of mining to the economy must be seen in its entirety, as coming not only from mining operations, but also from the downstream operations (Chamber of Mines, 2000). It is argued that “mining constitutes what is surely the most successful ‘cluster’ in the country’s economy” (Menell, 2000, 1).

Drawing on the Nordic experience of resource-based industrialisation, it is argued that by capitalising on linkages arising in the production chain there are three ways in which South Africa’s mineral wealth can be employed to ensure maximum industrial development. Firstly, through the development of downstream processing and beneficiation activities, secondly through the development of an upstream capital goods and services sector, initially supporting and dependent on the resource-based sector, but eventually emerging into an independent sector and generator of economic wealth in its own right. Lastly, the migration of generic technologies from the developed capital goods and services sector to other high-tech industrial sectors – the so-called lateral migration of technology (Vuori and Ylä-Anttila, 1992; Pajarinen *et al.*, 1998; *Mining Weekly*, 2001c).

Beneficiation

In contrast to manufacturing products, there has been a gradual decline in the real price of minerals and mineral-based products. This has largely been the result of a combination of different factors: a reduction in the intensity of use of traditional minerals and metals, increasing competition between mineral producers, technical developments lowering the cost of mineral extraction, as well as various economic and environmental factors. This has effectively led to a general deterioration in the terms of trade of raw material exporting countries and increasing volatility in export revenues. In line with international and national debates pertaining to the feasibility of resource-based industrialisation strategies, it is argued that since mining is a primary industry engaged in the exploitation of a national asset, in order to ensure increased export revenues and the sustainability of such an industrialisation strategy further processing of mineral resources through beneficiation prior to export is essential (Jourdan, 1992; 1994; RSA, 1998; *Engineering News*, 2000d; *Mining Weekly*, 2000d; DTI, 2002). Moreover, it has been pointed out that “only through beneficiation and downstream development can South Africa become a prosperous and developed country” (*Mining Weekly*, 2000d).

Value-added processing, or beneficiation, involves the transformation of the raw material (through the production process) using local resources (labour or capital), to a more finished product that has a higher value than the sale of the raw material for export. Beneficiation involves a range of different activities including large-scale, capital-intensive activities such as smelting and sophisticated refining plants as well as labour-intensive activities such as craft jewellery and metal fabrication (RSA, 1998). Each successive level of processing permits the product to be sold at a higher price than the previous product or original raw material and adds value at each stage. Beneficiation should aim at creating an integrated industrial ‘platform’ of feedstocks for component and, ultimately, original equipment manufactures (OEM) exports. Support for increased beneficiation carries both national (increased foreign exchange earnings) and local benefits. In the latter case, it is argued that when more capital is directed into and spent within a particular locality more money for wages becomes available and local economic opportunities increase as capital and resources are consumed through the construction of a new industry. The opposite effect is the loss of local and national revenues through ‘leakages’ in local spending (Jourdan, 1992; 1994; Minerals Bureau, 2001). Moreover, mineral-based intermediate and finished products generally do not suffer the same terms of trade decline and volatility that raw materials do. Examples from around the world also attest to the long-term benefits of fostering a diversified and vibrant downstream industry. Mineral-based industries can survive after the exhaustion of the original deposit by importing the necessary ore or concentrate. Indeed, while the ‘real’ domestic mining industry

in Finland has continued to wane, raw materials have been imported on large-scale from abroad. Local mining companies are now engaged in the further processing of these raw materials and have concentrated on their best areas of knowledge: iron, copper and nickel processing as well as organisation and raw material services. This arrangement has resulted in a strong competitive position in global export of certain mining-related goods and services (Saarinen, 2000).

During the 1990s the South African mining sector has undergone a major transformation away from gold into higher value-added mineral processing and manufacturing, becoming a world exporter of processed minerals as opposed to its previous role as a primary commodity exporter (Jourdan, 1994; Minerals Bureau, 2001). This transition can largely be attributed to the construction of a number of large-scale, resource-based investment projects (such as Columbus Stainless, Hillside Aluminium, Namakwa Sands and Saldanha Steel) in various parts of the country. Since 1994, investment in resource-based projects has accounted for half the recorded formal sector economic growth.

Despite these developments, it is argued that South Africa has the potential to further raise the proportion of beneficiated mineral output. It is maintained that South Africa is only at the first stage of beneficiation, characterised by capital-intensive plants with low employment levels engaged in the production of mass intermediate products. In order to progress it is essential to move beyond this stage to mineral-based product fabrication where levels of employment are significantly greater (Jourdan, 1994). It has been asserted that prior to 1994 the level of mineral beneficiation in South Africa was minimal as the country's industries were mainly geared to the local market as primary-based products rather than manufactured goods tended to dominate exports. This was due primarily to the small size of the domestic market. In addition, tariffs and pricing policies, a lack of production competitiveness and skills, and protection in the domestic market resulted in a low level of beneficiation (Jourdan, 1992; 1994; RSA, 1998). The lifting of sanctions, however, has increased the potential for further beneficiation. Jourdan (1992; 1994) asserts that the country has various advantages that favour increased levels of beneficiation. These include a large and diversified resource base; transport benefits accruing to beneficiation close to the resource location; a local skills base in engineering and technology; and, low energy costs (Jourdan, 1992; 1994; RSA, 1998). Nevertheless, a number of constraints have been identified that limit value adding initiatives, most notably the large-scale capital requirements needed by most projects; distance and access to international markets; skills shortages in certain technical and managerial categories; and, the impact of import parity pricing (IPP) which allows primary producers to charge more for the product locally than they do abroad (Jourdan, 1992; 1994; *Engineering News*, 2001a; 2002b). Since the mid-

1990s, the Government has become increasingly committed to ameliorating past inefficiencies and the passing of the *White Paper on Minerals and Mining Policy for South Africa* in 1998 highlights the Government's commitment to promoting and supporting beneficiation activities. Indeed, it has been pointed out that, "The aim of the [minerals and mining] policy will be to develop South Africa's mineral wealth to its full potential and to the maximum benefit of the entire population. Government, therefore, will promote the establishment of secondary and tertiary mineral-based industries aimed at adding maximum value to raw materials" (RSA, 1998, 19). In addition, in the proposed 'Integrated Manufacturing Strategy' the Government makes a commitment to continue to study local pricing structures and alternative strategies (*Engineering News*, 2001a; 2002b). Moreover, the document emphasises that beneficiation and the optimisation of value chains have a pivotal role to play in the future transformation of the economy (DTI, 2002).

Capital goods and services inputs

A recent study commissioned by the Chamber of Mines in co-operation with DME and NUM and conducted by the University of Cape Town, illustrates how South Africa has used its mining activities as a base to nurture a cluster of highly competitive mining and mineral processing-related goods and service industries, supporting both the local and international markets. There are three areas in which South African firms have a global competitive advantage: the innovation and development of new technologies; the provision of knowledge-based services; and, consultation and specialist mining contractors. South African firms are world leaders in shaft sinking and hoisting technology, cooling of deep mines, rock mechanics design, mining explosives, drilling equipment and abrasives, metallurgical processes and plants, and delivering intellectually based services to mines around the world. This competitive position has emerged largely as a consequence of both the domestic market demand for solving problems of mining at depth and the availability of the 'lab' (i.e. rock-face) for product and technology development (Chamber of Mines, 2000).

The overarching objective of fostering the development of linkages between the natural resource base and the emergence of a 'sidestream' capital goods and services cluster is to provide a base from which sustained diversification can occur. While initially supportive and dependent on the resource-based sector, increased diversification and technological spillovers into new firms results in an expansion of the initial cluster that eventually emerges into an independent sector and generator of economic wealth in its own right. The importance of the capital goods and service sector to the Finnish economy is

apparent in the fact that in 1994 as much as 90 per cent of high-tech equipment produced by companies such as Finnminers and Outokumpu were for foreign markets (Pajarinen *et al.*, 1998).

It is argued that there are numerous opportunities for developing and fostering additional competencies in mining related activities and broadening the existing 'sidestream' cluster. In the first instance, due to the finite nature of mining activities there is a constant need to establish new ones. According to NRCAN (no date, 8), the demand for goods and services required to keep mines operational throughout the world is estimated to be about US\$ 200 billion per year. The construction of new mines currently planned around the world is set to trigger an annual demand of approximately US\$ 50 billion. The market for goods and services required for mineral exploration, moreover, is valued at US\$ 3 billion per year. In terms of overall value added, the global mining industry is estimated to be worth about US\$ 1 trillion – approximately eight times the size of the South African economy (Chamber of Mines, 2000).

Secondly, given that each ore deposit is geologically unique, demand for goods and services tailored to meet specific country requirements ensures a constant flow of products and supplies and interaction at the global, national and at the local level. Once the deposits have been extracted, the ore must be processed and developed on an on-going basis in order to maintain production. Capital equipment, processing plants, consumables, and services are needed in each of these phases. In addition, the mining plant and infrastructure must be repaired and upgraded and, as the ore is exhausted, the mines must be closed. Each of these activities creates a steady need for a wide variety of direct and indirect 'sidestream' input industries supporting and enhancing the mining sector (NRCAN, no date; Warda, 2001).

Thirdly, very few countries are self-sufficient or competitive in all lines of mining products. In mining, as in other industrial activities, purchasing decisions are made largely on the basis of specifications and price. While mining companies purchase locally where possible, they nevertheless are forced to obtain a large mix of products from various sources around the world. Together, these factors contribute to maintaining and enhancing competitiveness within the global mining supplier network (NRCAN, no date; Warda, 2001).

Fourthly, a number of local industry conditions support the emergence of a capital goods and service export cluster in South Africa. Sybil Rhomberg, chairperson of the South African Capital

Equipment Export Council (SACEEC), asserts that “[South Africa’s] mining equipment suppliers, unlike most of the developed world, have the advantage of a local market for their products, which helps to sustain and improve the sector, resulting in improved technology and equipment customisation” (*Mining Weekly*, 2002, 2). Moreover, South African manufacturers have an advantage over their competitors in terms of the export of capital equipment given the current weakness of the rand against other major currencies. With regard to the ICT revolution, the increased globalisation of the industry, and concomitant pressures in terms of maintaining competitive prices and quality, South African capital equipment exporters have benefited from a reputation as a world-class source of technology and products” (*Mining Weekly*, 2000; 2001b; 2002).

While it has been pointed out that many local companies are increasing their technology and R&D budgets in order to take advantage of these local and international opportunities, a number of constraints currently prevent the full potential of the local supplier network from being realised. In particular, pursuing and maintaining an aggressive and successful marketing campaign in a foreign country is costly, and requires highly-skilled personnel familiar with the market. It is also time consuming, taking between two and three years from the initial contact meeting to the signing of the contract. In addition to this, the cost of capital, skills shortages, the HIV/Aids pandemic, difficulty in acquiring funding for development projects at the front end, distance from most export markets, inflation and low productivity, lack of export market knowledge, inefficient infrastructure to support foreign clients, and securing export finance are other obstacles faced by local exporters. The top South African mining capital equipment exporters at present include Bell Equipment, Multotec, Bateman Materials Handling and Osborn (*Mining Weekly*, 2000; 2001b; 2002).

While it has been asserted that “success in the export market will save the entire mining-equipment manufacturing sector” (*Mining Weekly*, 2000, 3), and that exports of mining-related goods and services have been increasing at an average of 13 per cent per year since 1992, and at 20 per cent over the past few years, reaching a total of R14 billion last year, it has been pointed out that mining-equipment manufacturing industry is still not doing nearly enough to develop the export markets. Rhomberg asserts that the reasons for this are two-fold (*Mining Weekly*, 2000, 3). First, there is a general reluctance within South African companies to adopt an international focus and to diversify their export base away from components and sub-components to offering complete solutions and systems. Second, there is a misconception amongst local manufacturers regarding the potential of the industry – while South African mining equipment is world-class, and usually cheaper than its international competitors, many local

manufacturers do not believe this. One of the key objectives of the SACEEC is to assist in overcoming these problems and to provide a facilitating environment for the growth of the sector through exports (*Mining Weekly*, 2000; 2002).

Lateral migration

The key to South Africa's economic growth lies in the 'lateral migration' of the knowledge and know-how embodied in the technologies and products developed to support and sustain the mining and minerals processing sector. While the development of 'downstream' and 'sidestream' linkages from a resource-based enterprise are critical for initiating a process of sustained economic diversification in a country, the international experience reveals that the real transition from a position as a resource-based economy to a high-technology, knowledge-intensive one requires identifying and developing the more dynamic linkages that arise in each of these phases of diversification (Porter, 1990; Vuori and Ylä-Anttila, 1992; Vuori, 1997; Pajarinen *et al.*, 1998; Wright, 2001). This means that the mining sector should not only be seen as a source of export commodities (metals and minerals), but also as an engine for the development of its inputs industry and the export of this industry's related services, namely capital goods and expertise in fields such as process control, construction equipment and materials-handling (Chamber of Mines, 2000; *Mining Weekly*, 2001c).

Expertise in areas such as remote sensing, process control, ventilation, pumping, and materials-handling, while highly-specialised and geared to deal with specific challenges associated with the mining and mineral processing sector, are nevertheless 'generic' technologies in that they can (with adaptation and innovation) be used in industries not necessarily resource-related, but where the technological process underpinning them is similar (Vuori and Ylä-Anttila, 1992; *Engineering News*, 2001e; *Mining Weekly*, 2001c). The experience of Bell Equipment, one of South Africa's leading exporters of capital equipment, is a classic example of how technology, initially designed to meet the challenges posed by a single industry, moved laterally into a variety of technologically similar, but sectorally different, applications (Kaplinsky and Mhlongo, 1997). Indeed, the company's very first rugged, self-loading trailer was designed and manufactured in 1954 in order to manage the difficult and laborious task of cane-cutting and loading. In the early 1980s, the principles of the three-wheeled cane-cutter and loader were applied to another segment within the agricultural sector, the timber industry, which was flourishing in Richards Bay. Diversification into mining-related activities commenced with the acceptance by a Vryheid mine for a coal-hauling contract. The inclusion of off-the-shelf technologies such as an automatic gearbox, engine and transmission and other modifications to the original loader resulted in the

emergence of the rugged, two-wheel driver rigid hauler, suited to deal with the conditions of the mining environment. Growth in the manufacture of such vehicles was boosted not only by links to the coal mining industry, but also by the emergence of a general engineering contracting sector around the Richards Bay harbour. Despite the closure of the mine several years later, diversification within the company continued. Two-wheel haulers were adapted, manufactured and commercialised for a range of different applications and included the development of a basic, cheap, rugged front-end loader in 1982. Although Bell Equipment retained its links with the forestry and sugar industries, throughout the 1990s much of the demand for front-end loaders and articulated dump trucks came from a local demand for bulk materials handling, particularly in the mining and resources and the construction sectors. Commenting on the experience of Bell Equipment, Kaplinsky and Mhlongo (1997, 82) note that “Bell progressed in an unplanned and stumbling manner through a pattern of linked and complementary product innovations. Equipment was designed to work in extremely tough terrain and operating conditions. Success has been sustained through invention, innovation and marketing”.

It has been pointed out that South African global expertise and leadership in biotechnology and information and communication technology developed for and through the mining industry. As these services are currently booming in the world market there is significant potential for South Africa to export such knowledge (*Mining Weekly*, 2001c, 12). Another example of how locally-developed technology can migrate laterally is for control software used in specific mineral processing activities to be modified and adapted for use in other resource-based industries such as sugar refineries, through the identification of the relation between much of the functions of the refineries and the generic nature of the software (*Engineering News*, 2001a). Moreover, given the high-tech and knowledge-intensive nature of mining and mineral processing products and processes, the scope for the development of lateral migration linkages into knowledge-intensive sectors such as medicine, space, aeronautics and defence is extensive. Indeed, in 1997 the Australian Defence industry undertook a project exploring the possibilities of developing a new method of submarine detection based on electromagnetic geophysical survey technology used in the mining industry (DSTO, 1997). This study illustrates the diverse possibilities offered by the lateral migration of generic technologies.

In summary, stimulating lateral migration linkages carries numerous economic benefits. Not only does it assist in generating greater technological competence in the local workforce and increasing the contribution of high-tech exports to total exports, but it also ensures a long-term and sustained approach to the management of a transient resource base – the competitiveness of the original resource-based is

maintained and broadened as it is gradually embedded into more and more sectors of the economy. It has been pointed out that there are two factors that are currently restraining the furthering of lateral migration in South Africa. First, there is an element of risk involved in laterally migrating technology, which often involves large companies competing with bigger firms in an unknown field. Second, the local mining cluster is knowledge-based and South Africa is fast losing engineers due to emigration. It is argued that further research needs to be undertaken in order to identify strategies capable of resolving and alleviating these restraints (*Engineering News*, 2001a).

Evaluating the potential of a resource-based sustainable development strategy in South Africa

According to the World Commission on Environment and Development (WCED) sustainable development can be defined as “development that satisfies the needs of the present without jeopardising the abilities of future generations to meet their own needs” (Barreto, 1995, 4). Furthermore, it is best understood as “a process of change in which the use of resources, the direction of investments, the orientation of technological development, and institutional change all enhance the potential to meet human needs both today and tomorrow” (Barreto, 1995, 5). It is evident from the international review of resource-based industrialisation strategies that in order to be effective a ‘resource-based sustainable development’ approach to industrialisation in South Africa requires careful planning and implementation and needs to complement and uphold the broader development goals of the country. Two key interconnected lessons arise from the historical experience of resource-based industrialisation strategies which are of relevance to South Africa. Firstly, it is not *what* is produced, but *how* it is managed that is of critical importance. Porter (1990, 15) states that “it is where and how effectively factors are deployed that proves more decisive than the factors themselves in determining international success”. Secondly, achieving and sustaining a high-growth development trajectory requires commitment and well-defined strategies at both the firm and government level. According to Porter (1990, 29), “government policy at the state and local level has an important role to play in shaping national advantage” and that “government, at all levels, can improve or detract from the national advantage”. Moreover, “[it is the] will and ability to make a concerted effort at work, in every individual and at every level of the workplace, that create[s] economic growth” (NUTEK, 2000). It is apparent from the Swedish, Finnish and American experience of resource-based industrialisation that natural resource endowments also require considerable investments and reinvestments before their full potential is realised. Underpinning Sweden’s current industrial policy is the recognition that “success is not achieved without a cost but instead requires that part of today’s resources be set aside for investments”. These investments include

both physical capital and the acquisition of knowledge about the resource base and the development of technologies to increase the value of the resource base. As the knowledge-intensity associated with resource-based industries increases, the base as a whole expands through exponential relations and linkages. These linkages make it possible for resource-related sectors to propel economic growth for extended periods of time. The larger the knowledge network the more dynamic the sector. Gylfason (1999, 7) points out that “high-tech trade seems more likely to encourage economic growth through technological spillovers than low-tech, labour-intensive trade”. In addition to the requirements identified above, a vibrant knowledge cluster requires a strong and supportive supplier base, access to leading technology and expertise, and access to outside sources of research and knowledge (Warda, 2001).

One of the key challenges currently facing South Africa is to integrate successfully into the global economy and capture the benefits of increased liberalisation. In order to achieve this, the industrial base of the country needs to be diversified away from its current dependence on mineral resources into high-tech, knowledge-intensive activities. This is apparent in the words, “Co-ordinated and concerted actions have to be taken to maximise the potential within our domestic economy, integrate beneficially into the global economy and build competitiveness based on increased knowledge intensity, value addition, wider and more equitable participation in the economy and regional production systems” (DTI, 2002, 3). Moreover, it is argued that “The challenge ... is to ensure that opportunities within the domestic economy are developed and integrated advantageously into both domestic and transnational value chains, in order to meet national socio-economic objectives” (DTI, 2002, 22). The Minister of Trade and Industry, Alec Erwin is confident that South Africa is on course to becoming one of the leading manufacturing economies in the world. This is apparent in the following statement: “I’m confident that South Africa will be like the Swedish economy – as you know, Sweden started as a resource-based economy but became a powerful industrial economy, and I’m confident that South Africa will do the same” (*Engineering News*, 2002a, 6).

Considerable progress has been made in South Africa towards realising this goal. Economic bases are stronger, the proportion of product inputs produced in South Africa has increased (the local content of products has doubled in the last decade), and there has been an increase in the beneficiation of natural resources. Combined, these factors have resulted in the development of increasingly sophisticated and comprehensive component supply chains within the South African economy, supporting manufacturing. Product quality has increased and various training initiatives and skill upgrading programmes have been adopted and initiated within firms, universities and research institutes in order to maintain this and this is projected to continue. Industrial efficiency has also improved and costs have decreased (Chamber of Mines, 2000; *Engineering News*, 2002). However, while there is a well-developed science and technology base in the country, it is argued that what is currently lacking in South Africa is a tight collaborative and co-

operative research environment. Close linkages between companies, universities and government R&D institutes, with a common purpose and vision and common reference points, are essential for sustained growth and development. Not only do linkages help to promote R&D and a means of commercialising the resultant technologies, but they also provided a source for their successful transfer from universities and R&D institutes to viable companies. In this way a transition can be made from pure research to applied research, and from product development to production (*Engineering News*, 2001c). The South African mining cluster possesses the three characteristics of a virtuous cycle industry capable of facilitating the country's transition to a high-tech state. First, knowledge spillovers resulting the close proximity of firms. Second, mutually beneficial interaction between mines and providers of technological inputs. Third, a highly-skilled knowledge-base (Chamber of Mines, 2000; Warda, 2001). Moreover, considerable success has been achieved in downstream processing and the further beneficiation of the mineral resource base. However, it is argued that further research is needed into exploring the micro-dynamics of the domestic mining cluster; the factors and necessary macroeconomic conditions required to ensure lateral migration linkage creation; and, strategies for nurturing and protecting the knowledge and technology developed around mineral resources, before such an approach can be formulated into a viable and implementable industrial strategy (*Mining Weekly*, 2001a; 2001c)

Conclusion

It is evident that a rich endowment in natural resources, combined with the aggressive pursuit and adoption of new technologies appropriate to them, can provide the basis for sustained and long-term economic growth and development. Indeed, Sweden, Finland and the United States provide evidence of countries that have successfully used their resource base to catapult them into globally competitive industrial nations. The development gains obtained from South Africa's rich mineral endowment have, to-date, been limited. There is both a challenge, represented by the successful examples of resource-based industrialisation, and an imperative, represented by the transient and cyclical nature of minerals and the critical unemployment crisis in the country, to diversify production away from a current reliance on natural resources into high-tech and knowledge-based activities. South Africa is faced with three possible industrial development trajectories. First, greater downstream beneficiation, especially in component manufacture with its relatively high employment intensity. The single biggest constraint preventing acting against further downstream processing is the practice of import parity pricing. Second, facilitating the growth of the domestic capital goods industry based on the competence already developed in the mining inputs sector. Third, stimulating the lateral migration of generic technologies based on

mineral extraction, refinement and processing activities. While further research is needed on the latter two options before the full potential of the sector can be realised, what is apparent from the international experience is that for a ‘resource-based sustainable development’ approach to be successful, engendering a high level of human capital and developing a capacity for ‘national’ learning and innovation is of fundamental importance.

References

- Abedian, I. And Standish, B., 1992: The South African economy: an historical overview, in I. Abedian and B. Standish (eds.), *Economic Growth in South Africa: Selected Policy Issues*, Oxford University Press, Cape Town, 1-24.
- Ali-Yrkkö, J., Paija, L., Reilly, C. and Ylä-Anttila, P., 2000: Nokia – A Big Company in a Small Country, *ETLA Discussion Document*, B162 Series, Taloustieto Oy, Helsinki.
- Altamirano, N., 1999: Sustainable Development and Exhaustible Resources: The Dutch Disease is not a Disease at All, *IR/PS Research Report*, No. 99-08, Graduate School of International Relations and Pacific Studies, University of California, San Diego.
- Altman, M., 2001: Employment promotion in a minerals economy, Paper prepared for WORK2001 First International Conference on Employment Creation in Development, University of the Witwatersrand, Johannesburg, 2-5 April.
- Archer, S., 1987: South Africa's industrial experience in perspective, *Social Dynamics*, 13 (1), 31-46.
- Arkwright, D., de Beer, G. and Mmatli, R., 1998: Spatial Development Initiatives in South Africa: Progress Achieved and Future Objectives, Unpublished paper presented at SAPES Trust Annual Colloquium, Harare, September.
- Auty, R.M., 1989: The internal determinants of eight oil-exporting countries' resource-based industry performance, *Journal of Development Studies*, 25 (3) 353-373.
- 1991: Third World response to global processes: the mineral economies, *Professional Geographer*, 43 (1), 68-76.
- 1995: *Patterns of Development, Policy and Economic Growth*, Edward Arnold, London.
- Ballance, R.H., 1987: *International Industry and Business: Structural Change, Industrial Policy and Industry Strategies*, Allen & Unwin, London.
- Barreto, M.L., 1995: Sustainable Development: Concepts, in R.C. Villas Bôas (ed.), *Sustainable Development and the Advanced Materials: The Brazilian Case*, CETEM/CNPq, Rio de Janeiro, 3-9.
- Black, A. and Stanwix, J., 1987: Manufacturing development and the economic crisis: restructuring in the eighties, *Social Dynamics* 13 (1), 47-59.
- CDE (Centre for Development and Enterprise), 1998a: Growth, employment and economic policy in South Africa: a critical review, *CDE Focus Series*, Occasional paper for the Centre for Development and Enterprise (CDE), Johannesburg.
- 1998b: Labour-demanding growth: lessons from the international experience?, *CDE Focus Series*, Occasional paper for the Centre for Development and Enterprise (CDE), Johannesburg.
- Chamber of Mines., 2000: *The South African Mining Industry in the 21st Century*, Chamber of Mines, Johannesburg.

- Chang, H-J., 1998: Evaluating the current industrial policy of South Africa, *Transformation*, 36, 51-72.
- Davis, G.A., 1994: *South Africa's Managed Trade Policy: The Wasting of a Mineral Endowment*, Paeger, Westport.
- 1995: Learning to love the 'Dutch disease': evidence from the mineral economies, *World Development*, 23 (10), 1765-1779.
- Department of Finance., 1996: *Growth, Employment and Redistribution: A Macro-Economic Survey*, Department of Finance, Pretoria.
- DTI (Department of Trade and Industry)., 2002: *Accelerating Growth and Development: The Contribution of an Integrated Manufacturing Strategy*, The Department of Trade and Industry, South Africa.
- DSTO., 1997: Conductivity contrast a giveaway, *Australian Defence Science News*, www.dsto.defence.gov.au/corporate/publicity/articles/adsn167.html
- ECA (Economic Commission for Africa)., 2001: *Enhancing Africa's Competitiveness: Policy Issues in Natural Resources and Science and Technology*, ECA, Notes from the Secretariat, June.
- Engineering News., 1999: Don't just mimic developed world – Chile, *Martin Creamer's Engineering News*, 26 November – 2 December, 9.
- 2000a: South Africa must become a knowledge-based economy, *Martin Creamer's Engineering News*, 14-20 July, 45.
- 2000b: Business calls for common economic vision, *Martin Creamer's Engineering News*, 22-28 September, 21.
- 2000c: Erwin unveils strategy to boost manufacturing, *Martin Creamer's Engineering News*, 29 September – 5 October, 7.
- 2000d: South Africa will have to 'go downstream', *Martin Creamer's Engineering News*, 3-6 November, 5.
- 2001a: Neutralise import parity pricing to advance lateral migration *Martin Creamer's Engineering News*, 18-24 May, 10.
- 2001b: Finns illustrate benefits of R&D, *Martin Creamer's Engineering News*, 14-20 September, 51.
- 2001c: SA should follow Finn's approach, *Martin Creamer's Engineering News*, 5-11 October, 6-7.
- 2001d: World Bank mulls SA's growth dilemma, *Martin Creamer's Engineering News*, 5-11 October, 21.

- 2001e: Mining in the knowledge-based economy, *Martin Creamer's Engineering News*, 12-18 October, 11.
- 2002a: SA an emerging manufacturing giant, *Martin Creamer's Engineering News*, 8-14 February, 6.
- 2002b: State to study import parity pricing issue, *Martin Creamer's Engineering News*, 3-9 May, 12-13.
- Fine, B. and Rustomjee, Z., 1996: *The Political Economy of South Africa: From Minerals-Energy Complex to Industrialisation*, Witwatersrand University Press, Johannesburg.
- Gylfason, T., 1999: Natural Resources and Economic Growth: A Nordic Perspective on Dutch Disease, *UNU/WIDER Working Paper*, No. 167, UNU/WIDER, Helsinki.
- 2001: Lessons from the Dutch Disease: Causes, Treatment, and Cures, Institute of Economic Studies Working Series W01:06, University of Iceland, Reykjavik.
- Hägglom, R. and Vasara, P., 1999: Smart paper for a smarter forest cluster, *Pulp and Paper Technology Review*, FINPRO, Helsinki, 6-7.
- Herring, P., 2001: Driven by technology, *High Technology Finland 2001*, TEKES, Helsinki, 11-14.
- Hirsch, A. and Hanival, S., 1998: Industrial Restructuring in South Africa: the Perspective from Government, Paper presented at the Trade and Industry Secretariat (TIPS) 1998 Annual Forum, 20-22 September, Muldersdrift.
- Humphreys, D., 2000: Mining as a Sustainable Economic Activity, Paper prepared for an informal seminar on the Mining and Metals Industry, OECD, Paris, 9 February.
- Jourdan, P., 1992: *Mineral Beneficiation: Some Reflections on the Potential for Resource-based Industrialisation in South Africa*, Economic Trends Research Group, Working Paper No. 14, University of Cape Town School of Economics, Cape Town.
- 1994: South Africa's Mineral Beneficiation Industries and the Potential for Mineral-based Industries, Unpublished Masters Thesis, University of the Witwatersrand, Johannesburg.
- Kaplinsky, R. and Mhlongo, E., 1997: Infant industries and industrial policy: a lesson from South Africa, *Transformation*, 34, 57-85.
- Karppi, I., 2001: Competitiveness in the Nordic Economies: Assessment and Structural Features, Working Paper 2001:2, Nordregio, Stockholm.
- Lawrence, R.Z., 1993: Trends in world trade and foreign direct investment, in P.H. Baker, A. Boraine, and W. Krafchik (eds), *South Africa and the World Economy in the 1990s*, Rustica Press, Cape Town, 2-31.
- Leipziger, D.M., 1993: *The Lessons of East Asia: An Overview of Country Experience*, World Bank, Washington DC.

- Mainardi, S., 1997: Mineral resources and economic development: a survey, *Development Southern Africa*, 14 (1), 61-77.
- Menell, R.P., 2000: Key challenges for the 21st century – finding a common base, Address given by the president of the Chamber of Mines at the Mining Summit, Pretoria, 25 February.
- Minerals Bureau., 2001: *South Africa's Mineral Industry 1999/2000*, Minerals Bureau, Department of Minerals and Energy, Pretoria.
- Mining Weekly., 2000: Equipment makers lack oomph, *Mining Weekly*, 2 September – 5 October, 3.
- 2001a: Research to promote more use of downstream resources, *Mining Weekly*, 24-30 August, 4.
- 2001b: The globalisation of South Africa's mining industry, *Mining Weekly*, 7-13 September, 38.
- 2001c: Fighting the 'natural-resource curse', *Mining Weekly*, 9-15 November, 12.
- 2002: SA's top five mining capital equipment exporters, *Mining Weekly*, 17-23 May, 2-3.
- Nankani, G., 1979: *Development Problems of Mineral Exporting Countries*, World Bank Staff Working Paper 354, World Bank, Washington DC.
- NRCAN (Natural Resources Canada)., no date: *Canadian Suppliers of Mining Goods and Services*, NRCAN, Canada.
- NUTEK (Swedish National Board for Industrial and Technical Development)., 2000: *Swedish Industry and Industrial Policy 2000*, NUTEK, Stockholm.
- Östensson, O. and Uwizeye-Mapendano, A., 2000: Growth and Diversification in Mineral Economies, Draft paper prepared for the regional workshop for mineral economies in Africa, Cape Town, 7-9 November.
- Pajarinen, M., Rouvinen, P. and Ylä-Anttila, P., 1998: Small Country Strategies in Global Competition: Benchmarking the Finnish Case, *ETLA Discussion Document*, B144 Series, Taloustieto Oy, Helsinki.
- Porter, M., 1990: *The Competitive Advantage of Nations*, MacMillan, London.
- Roemer, M., 1979: Resource-based industrialisation in the developing countries: a survey, *Journal of Development Economics*, 6, 163-202.
- Rostow, W., 1962: Some Lessons of History for Africa, Paper presented at the Third Annual Conference of the American Society of African Culture, University of Pennsylvania, Philadelphia, 22-26 June.
- Rouvinen, P., 1996: *Advantage Finland: The Future of Finnish Industries*, ETLA/SITRA, Helsinki.
- RSA (Republic of South Africa)., 1998: *White Paper: A Minerals and Mining Policy for South Africa*, Department of Minerals and Energy, Pretoria.

- Saarinen, J., 2000: Innovation Activity in Finnish Industries – A New Pattern, Lund Papers in Economic History, No. 69, Department of Economic History, Lund University, Lund, Sweden.
- Sengenberger, W., 1993: Local development and international economic competition, *International Labour Review*, 132, 313-329.
- Vogel, E.F., 1991: *The Four Title Dragons: The Spread of Industrialisation in East Asia*, Harvard University Press, Cambridge Massachusetts.
- Vouri, S. and Ylä-Anttila, P., 1992: Industrial Transformation in Finland – From Factor Driven to Technology-based Growth, *ETLA Discussion Document*, No. 413, ETLA, Helsinki.
- Vuori, S., 1997: *Technology Sources and Competitiveness – An Analysis of Finnish Industries*, ETLA, Taloustieto Oy, Helsinki.
- Warda, J., 2001: *Investing in Innovation in the Resource Sector: Industry Needs, Barriers and Opportunities for Action*, Innovation and Knowledge Management, Conference Board of Canada, Ottawa, February.
- Wright, G., 2001: Resource-based Growth Then and Now, Paper prepared for the World Bank project “Patterns of Integration in the Global Economy”, June.
- Ylä-Anttila, P., 2000: Nokia and Oulu – National and Regional Growth Drivers in Finland, Paper presented at the seminar Verdiskaping, kompetanse og innovasjon, mot en ny politikk for nyskaping og næringsutvikling, Oslo, 8 May.