

Identifying Technologies to License

Identification of key products and technologies by means of systemized procedure; practical example

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The important and rapidly increasing role of technology in everyday life and business has become self-evident. Digital watches and office automation are examples. In some circles concern has been expressed about the speed that technological change is taking place, for example, Alvin Toffler's book *Future Shock*.

Rapid change has become possible because entrepreneurs are becoming more expert in applying new technology. This expertise has become more and more a competitive factor in the modern business environment.

What we are talking about is technological innovation, that is, the development and commercialization of new products and processes. Technological innovation is an essential element of a strong and growing economy. It helps ensure economic vitality through improved productivity, international competitiveness, job creation, and an improved quality of life for each South African. Further, industrial innovation is necessary if we are to solve some of our countries' most pressing problems—for example, reducing inflation, providing new energy supplies and better conservation of existing supplies, ensuring adequate food for our population, optimum utilization and exploitation of our water resources.

Where is all of this leading? Very simply, to a well-known economic concept known as "the optimum utilization of scarce resources."

The favorable manufacturing conditions in South Africa have created excellent opportunities for the local production and export of industrial products. Local manufacturers have the advantage of relatively cheap labor, and land and indigenous raw materials combined with other incentives such as tax and development cost rebates.

Trade statistics clearly illustrate South Africa's dependence on trade, both imports and exports, for sound economic growth. The importance of external trade in the South African economy is illustrated by

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the following: In 1980, imports, exports and gold sales amounted to 58.6% of the GDP. In comparison, during 1975 the proportion was 50.2%. Excluding gold the figures were 41.2% and 40.4%, respectively. It is our view that this dependency is unlikely to decrease since trade tends to grow with industrial development.

From a global viewpoint, the most valuable resources of the Republic of South Africa (RSA) are the rich and varied mineral deposits. These mineral and energy products provide a strong base for the South African economy and offer excellent potential for increased processing in the country, thereby contributing to the development of secondary industry.

Although economy of scale has been put forward in numerous cases as a major inhibiting factor for local production, lucrative export markets are presently being served by South African producers in many instances.

THE RESEARCH AND DEVELOPMENT POSITION

For sustained growth and further development of the local manufacturing sector, the maintenance and expansion of a strong technology base is self-evident.

But how do we feature on the R&D scene?

- The RSA expenditure on R&D as a percentage of GDP was only 0.64% during the financial year 1979-80, which is low according to international standards.

- The growth rate for total R&D expenditures (in real terms) amounted to only 5% compounded over the period 1969-70 to 1979-80.

- During 1979-80, R310 million was spent on R&D in the RSA contributed by:

Government sector	49%
Tertiary education sector	16%
Business sector	34%
Nonprofit sector	1%

From the above it is clear that the government sector plays a proportionally larger part than the other sectors, which is contrary to the position in most developed countries, where the universities and in particular the business sector fulfill a more important role. What is even more disconcerting is that only R103 million or 31% of the R&D budget is spent in the

business sector. The need for the identification and development of key technologies therefore becomes very important.

WHAT IS A KEY TECHNOLOGY?

A key technology can be defined as a technology (existing, being developed, emerging, or for which as yet only a need exists) that promises to play an important role in the economic, social or strategic development of resources in South Africa. Due to the mentioned limited R&D resources, a definite need exists to concentrate R&D efforts on key technologies on a broader base, to include research that cannot be accommodated under one roof.

The Group for Techno-economic Studies (GTES) of the Council for Scientific and Industrial Research (CSIR) has set itself the task of identifying these key technologies and then conducting an evaluation to determine what contribution can be made to such research by the CSIR, industry or universities, or collectively by several interested organizations.

IMPORTANCE OF KEY TECHNOLOGIES

The Kleu Committee report on Industrial Strategy gives specific attention to technological innovation as illustrated by the following quote: *"To ensure the optimal integration of the national economic, industrial and technological objectives, it would be necessary to coordinate all these facets at one point. The best results in this connection will most probably be achieved if continuous attention by a policy committee be given to these facets based on key technologies as identified by the CSIR. The policy committee would be chaired by the Economic Advisor to the Prime Minister with representation from the Department of Industries, Trade and Tourism, the Board of Trade and Industries, the Industrial Development Corporation, the Department of Manpower, the CSIR and the SABS."*

The emphasis placed on a coordinated approach directed at the development of key technologies is self-evident.

Another reason why careful attention should be given to key technologies is their importance for import replacement. It is perhaps of significance to note that imports doubled in money terms from 1975 to 1980, but adjusted to 1975 prices they actually decreased steadily to a level still below 1975 values. But, according to a recent survey, it is estimated that spending on import replacement ventures will be R9 100 million over the next five years. The breakdown is as follows:

Synfuel projects	R7 500 million
Fuel replacement services	R400 million
Metal and chemical import replacement	R1 200 million

The importance of the development or adaptation of key technologies to meet these challenges is self-evident. Coal liquefaction technology is a good example.

The need for beneficiation of raw materials has already been mentioned. It is therefore accepted that the country's comparative advantage will be derived mainly from its abundance of natural resources, which

will enable it to export successfully manufactures based on minerals, biological resources and chemicals, many for which key technologies have already been identified.

The major growth areas of South African exports are easily identified in Table I.

	1980 Adjusted for 1975 values Rm	1975 Values Rm	% Change
Vegetable products	456	543	-19
Foodstuffs, beverages	405	524	-29
Chemical products	872	388	+55
Pearls, precious stones and metal coins	1,599	995	+38
Base metals and articles thereof	888	486	+45

TABLE I

Thus, from this table it can be concluded that products of the SA mining industry constitute a growing majority of the country's exports offering excellent opportunities for research and technological development.

When key technologies are discussed, the problem of job creation very strongly comes to the fore. The RSA does not now conform, nor has it conformed in the past, to the general guideline that developing countries should direct their efforts toward labor-intensive industrial production.

Till now our country's exploitation of natural resources, rather than labor, has been the major source of industrial growth. Our scarce capital resources have always been applied primarily to processing agricultural and mineral resources rather than to developing the quality of labor resources.

Job Creation

The implications of job creation for the country's fast-growing population are staggering. It is estimated that over the next 20 years the country will need to invest nearly R150 billion *at today's values* to provide employment for the 7 million workseekers.

The need for development of *appropriate technology* is therefore self-evident. Key technologies are required that will provide an acceptable balance between optimum job creation and low product unit price, thereby enabling such products to compete with imports as well as on the export market.

Another very important area where key technologies feature strongly is the strategic needs of the country, and one would think of strategic needs in both the military and nonmilitary sense.

On the military side the phenomenal growth of the armaments industry speaks for itself. Locally-developed-and-adapted technology features very strongly, for example, development of critical components such as specialized micro-circuitry, development of new weapons systems, and the development of more effective and cheaper components and military transport vehicles.

On the nonmilitary side, specific strategic-related key technologies have been developed or adapted for water purification and recycling, low-cost housing, and liquid fuels, to name a few examples.

Key technology identification, development or adaptation to serve the strategic needs of the country is therefore an important part of the country's technology-development strategy.

HOW ARE KEY PRODUCTS AND TECHNOLOGIES IDENTIFIED?

This problem can be approached in two ways, namely, on an ad-hoc basis or systematically. The GTES has developed a procedure that follows the systematic approach and basically covers the following aspects:

1. Identify key sectors of the manufacturing industry for which key technologies should be identified first, using:
 - Economic statistical parameters (import replacement).
 - Economic and industrial policy guidelines (Kleu report).

The chemical, pharmaceutical, metals and metal products and biological resources sectors have already been identified and are currently receiving attention.

2. Assess the techno-economic aspects of these key sectors, especially:
 - Innovation status of the sector (including reasons for poor innovation record).
 - The technological needs of the industry (R&D survey).
 - Technoeconomic trends in the sector (including technological forecasting, scenarios).
3. Evaluate industrial research and supply of technology for the specific sector, especially:
 - R&D expenditure pattern.
 - Availability and quality of technology and expertise available for industry.
4. Assess effects of other factors on technological development of sector, for example:
 - Industrial policy.
 - Patent policy.
 - Fiscal and monetary policy.
5. Identify key products and technologies, with reference to:
 - Short-term threats and opportunities.
 - Medium- and long-term threats and opportunities.
6. The last step would then be to evaluate the relative significance of key technologies and then formulate recommendations for support of industrial R&D.

EXAMPLES OF IDENTIFIED PRIORITY SECTORS

The identification of priority sectors could be approached in many ways, for example: Following the oil crisis there was a specific need to reduce the RSA's dependence on imported crude oil—derived chemicals and the chemical sector was therefore identified as a priority sector. In studies pertaining to this sector strong emphasis was initially placed on identifying import replacement opportunities.

As recommended by the Kleu report, more emphasis should be placed on export promotion and the GTES is therefore taking a fresh look at priority sectors. For example, in the attached graph the trade balance, ex-

RSA TRADE BALANCE: 1975 - 1982

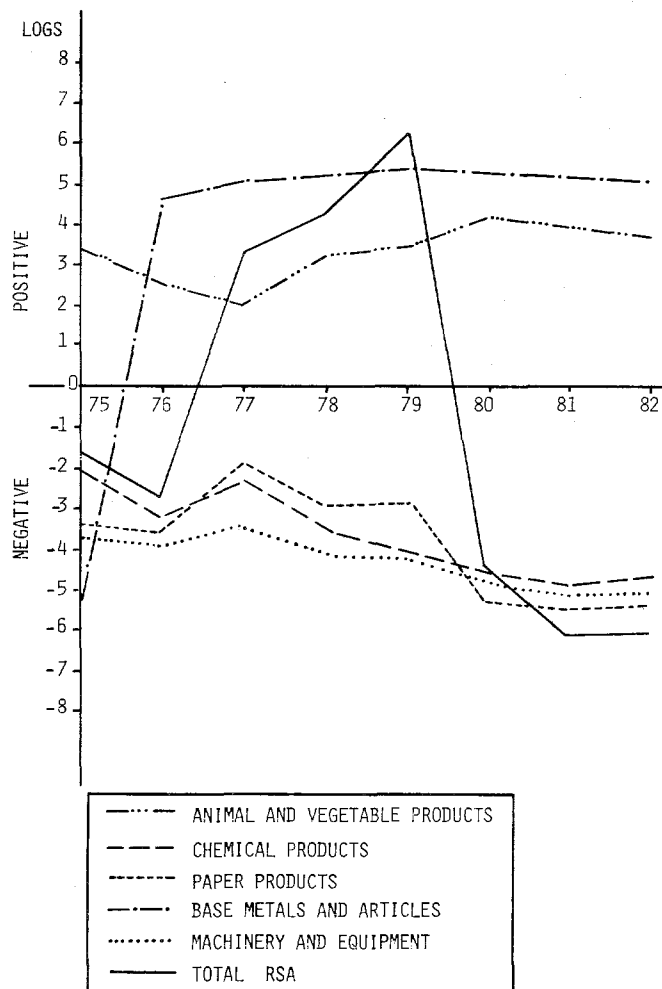


TABLE II

pressed as a percentage change from year to year is given, starting at base year 1974. From the graphs it is important to note that the favorable trade balance for animal and vegetable products as well as base metals and articles of base metals has levelled out and is starting to follow a downward trend. Many explanations could be offered for this trend but obviously here is a strength that should be carefully evaluated for technological improvement and innovation.

As far as the trade balance for paper and paper products, chemical products, and machinery, as indicated on the graphs is concerned, one notices that after an upturn in 1977, the trade balance has followed a continuing downward trend, although a bottoming out is noticed from 1981. Clearly, these three sectors invite further investigation to establish what contribution technological innovation could make.

Three manufacturing sectors have been identified for further investigation: chemicals, metals and metal products, and food.

THE CHEMICAL INDUSTRY

Studies by the GTES have confirmed that South African industries generally find it difficult to compete in the primary manufacture of chemicals, especially

organic chemicals, due to the economy-of-scale advantages that large overseas companies enjoy. During the past few years the chemical industry in the northern hemisphere has been hard pressed to keep capacity at minimum levels, due to the recession. This has led to very competitive world prices. Consequently, in South Africa it is very difficult to identify opportunities for economical local production of chemicals.

The GTES recently started to concentrate on identifying import replacement opportunities and key technologies in areas where the country can utilize more fully its available raw materials, and to beneficiate for export or concentrate on serving specific local markets.

The use of chemicals in the metal finishing industries is at present under investigation and especially chromic acid is of interest. To illustrate:

- Approximately R1 million worth of chromic acid is imported while SA is one of the exporters of CrO_3 .

- Chemicals used in the food industry are also being investigated. For example, ascorbic acid to the value of R3 million is at present imported mainly for use in the food industry.

- Ammonium sulphates can be produced from waste gypsum, yet there is still a sizable import of this product.

- Calcium carbonate is a chemical with many diverse uses and the technological challenge is to find what exact uses it is put to and to utilize the available deposits of this chemical more fully by refining and finely grinding to supply the local market.

- The GTES has previously undertaken a study of terephthalic acid, which is used extensively in the manufacture of plastic fibres, films and resin. Unfortunately, SASOL yields very little by way of aromatics, the required feedstock.

- Another plastic feedstock is epichlorohydrin, which is used in the manufacture of epoxy resins. All the raw materials necessary for its manufacture are available locally but the present imports are about 60% of the expected minimum viable size of a plant.

- Methylamines have also been investigated, but seem to be non-viable at this stage due to the small local market. These three technologies do not seem viable at present, but warrant continued monitoring.

- A key technology that is proving extremely successful is furfural and furfural alcohol produced from the waste product of sugar cane milling, bagasse. A local company manufactures and exports these chemical solvents quite successfully. In general the better utilization of bagasse and sucrose as feedstocks for the production of chemicals should receive close attention.

The GTES will obviously also continuously monitor developments in the field of biotechnology in order to identify products that could possibly be produced economically from available local resources. In most cases, chemicals, enzymes and biomedical products will not be produced locally due to considerations of economies of scale and very high technical competence levels required. Nevertheless, certain applications such as in agriculture and biomass conversion warrant continued monitoring. In this connection the President of the CSIR recently announced establishment of a facility to support the development of molecular-biology in

the RSA.

THE METALS AND METAL PRODUCTS INDUSTRIES

Studies by the GTES point to a need for a technological strategy to achieve two specific national objectives— export drive and energy consumption improvement.

The processing of metal ores and production of metal products are important areas for further analysis:

- The need has been identified for new smelting techniques for ferro-alloys to keep costs down and reduce energy needs. Plasma smelting could be a technology that becomes widely used. The problem is that costs are relative to competitors' prices, and technologies used locally are relative to technologies used by competitors abroad. Advantages are needed if exports are to be sustained economically.

- Second, the needs of industry are for more special steels for military and industrial applications. Refining of metals and alloying technology (high-quality steels) must be expanded. World trade is becoming more restrictive, despite GATT, and the advanced technology of metals is one way of ensuring that manufactured products remain technically competitive. For example, the welding of a special tough steel may be a simple innovative technique, but it helps a product costing a few hundred thousand rand to compete technically.

- Third, metal product exports make up an important portion of exports of industrialized nations, usually between 25 and 50%. This is one feature that distinguishes them from underdeveloped countries. If South Africa wants to emulate their development, then metal product exports must be greatly increased (at present it is only 2.5%). Exportable manufactured products must be identified where competitive advantages can be gained. To build on our known strength one would immediately think of mining equipment. Why can South Africa not become the major mining equipment manufacturer in the world? The key technologies for equipment manufacture must be developed further for sustaining exports.

Energy supply and consumption is another important area:

- Coal conversion to energy is a technology that needs to be expanded in view of South Africa's coal reserves, not just multiples of SASOL but all forms of conversion to energy, to materials, to liquids, etc.

- Energy is vital to the economic survival and development of a country. We must diversify energy consumption patterns to avoid vulnerability. The technology to use other forms of energy should be developed. Economics will channel the consumption to the technology most suitable at a given time. For this reason electrical vehicles can be considered as an alternative, and the key technologies of such a system are:

1. Energy storage—battery systems must be developed for commercial exploitation, and the materials needed for their manufacture economically produced.

2. Electric motors—optimum motor design and mass production techniques are needed.

3. Electric controllers—the cost of control systems

must be reduced.

THE FOOD INDUSTRY

The useful role that new technologies can play in the supply of better and cheaper foods is undeniable. Better technology can be employed in agricultural production of food mainly to increase yields and produce vegetable products that lend themselves to processing. Minimization of food losses after harvesting can be assured through better processing technology. To process, preserve and supply nutritious food of high quality and which represents good value for money, should be a major objective of food industries.

Although South Africa is often erroneously labelled the "food pantry of Africa," very little food in processed form is exported. With the exception of canned fruit and sugar, South Africa exports mainly unprocessed food. The South African trade balance is processed food products is declining.

Certain new, but at the same time feasible technologies that are and can in future play a useful role in the food industry are the following:

- Concentration of liquid products such as fruit juices and partial dehydration of fruits and vegetables in order to save on the high transport costs that are pricing South African products out of overseas markets.

- The irradiation of fresh foods to prolong their

useful shelf life.

- Processing methods that can minimize energy inputs and maximize nutrient retention of foods.

- Cheap methods to preserve fresh, deleafed vegetables to cut down the transport and handling cost.

- New, convenient packs and containers to replace the tin can, e.g. retortable pouches. Unfortunately, the production rates attainable with these containers is still far lower than of cans.

SUMMARY

Full support is given by the GTES to the Kleu investigation findings that technological innovation has an extremely important role to play in the economic development of this country. Various key technologies as indicated have already been identified and are currently under investigation.

We also believe that technological innovation should be dynamic. It should, however, not only follow structural changes but also exploit new areas. It should not only be reactive but also pro-active. To this end the CSIR makes an important contribution through the identification of key technologies by means of a systematic approach and financial backing of the development of these key technologies in research organizations and in industry.