EMERGING FROM THE TECHNOLOGY COLONY: A VIEW FROM THE SOUTH

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Abstract -This paper explores the notion that, even though many developing countries of the world gained political independence after WW-II, they essentially remained "technology colonies". A definition of the technology colony is developed, to serve as framework for the development of guidelines to grow out of this mind set towards national independence, also with respect to the technological dimensions of the national economic system. Being a technology colony is neither something to be ashamed of, nor necessarily a disaster. Remaining one, should not be a fate to be suffered, but an opportunity to be managed.

HISTORY

Even though many countries of the world gained political independence after WW-II, they essentially remained "technology colonies". This has had the effect of delaying, if not thwarting the economic development of such countries and could be one of the major reasons for the acrimonious debate between "the North" and "the South". The frustration of former (political) colonies arises from a failure to achieve the economic growth, necessary for the improvement of the quality of life of their citizens. They tend to blame this failure on the poor point of departure for their development trajectories, that was the legacy of their colonial masters. The former colonial powers on the other hand, tend to be so hard put competing and surviving in the modern global market place, that they find it extremely difficult to devote significant time and effort towards the resolution of the problems of the "colonies", especially if it involves the redress of historical disadvantages, created by previous generations.

Both parties in the debate find themselves poorly served by their economic advisers, since these experts tend to have a limited understanding of the technological factors that need to be taken into account when former political colonies have to also become technologically "independent".

FEATURES OF THE TECHNOLOGY COLONY

The general notion of a technology colony could be explained by means of the diagram in Figure 1, where the levels of activity

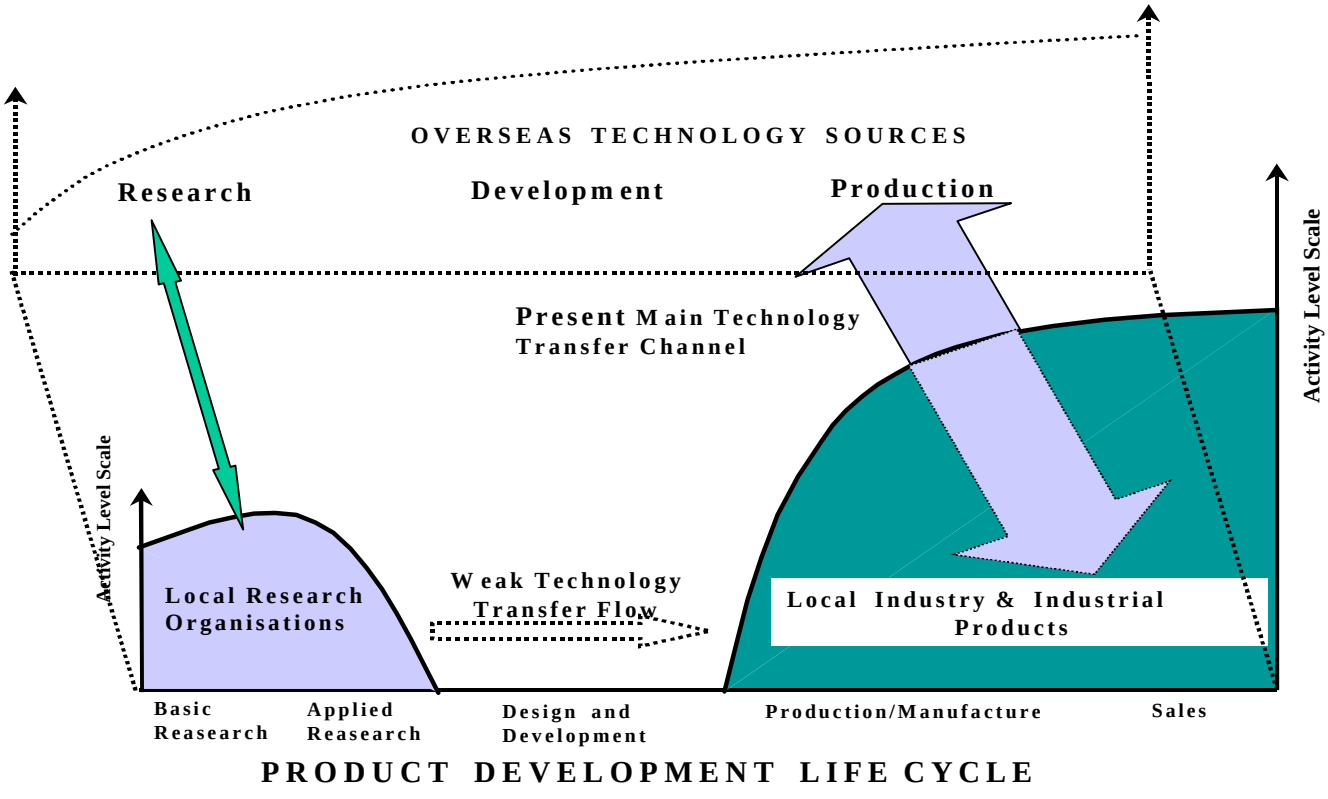

Figure 1: Technology transfer channels in the Technology Colony

(in terms of monetary value) is plotted over the product life cycle.

These levels of activity in the technology colony in the foreground, are compared to the levels in the generic, industrialised, First World country in the background. This presentation provides the first general features of the technology colony, as follows:

- the predominant industrial business activity in the colony is at the manufacture and "trade-in-final-products" end of the product life cycle, while activities in the industrialised country tend towards a continuum over the whole life cycle
- there is a small group of activities at the research end of the life cycle in the colony, representing the R&D activities of tertiary education institutions, some R&D done in local industry and some government-funded R&D
- there is a large flow of technology from the developed world into the colony, in the form of licensed product designs, processes, subassemblies and final products, often implemented in the colony in the form of a subsidiary of a multi-national corporation
- there is an almost insignificant flow of technology from the local R&D community to the local industrial sector, mainly because the relevant R&D is done "back home"; but there is some communication between the local and foreign R&D communities.

In the case of South Africa, more than 80% of the value in industrial business activity is done under (foreign) licence, and more than 50% of this activity is subject to market constraints.

STRATEGIC BUSINESS ALTERNATIVES FOR TECHNOLOGY COLONIES

Deriving benefit from colonial status:

Broadly speaking, the strategic issue for the technology colony is how to grow its economy beyond the limitation of its domestic market. Stated differently, the primary consideration for establishing a subsidiary of a multi-national in a given country, is to serve the market in that particular country, and possibly that region, but not necessarily to supply the rest of the world from that base. So the capacity of the subsidiary will be determined by the size of the relevant market, rather than by total global demand, and the decision about this capacity is taken at the headquarters of the multi-national rather than by the government of the relevant country. If the colony therefore has to grow its economy in any significant way, it would have to identify opportunities to export to a market beyond the local limits. This leads to the question: under what circumstances would the colony have the option of exporting at the desired level? The answer is rather obvious, i.e. that exports would make business sense if they could be achieved at the desired level of quality and at a better price than from anywhere else.

Many countries have made a tremendous success of being technology colonies. The "little dragons" of the Pacific rim have developed this approach to a fine art, with Singapore probably the most sophisticated example. The question of the extent to which this was an intentional strategy rather than a pragmatic recognition of the fact that, in the absence of other natural resources, the human resource had to be utilised to obtain the maximum benefit, has to remain open. The observation is simply that "technological colonialism" paid handsome dividends to these countries, provided that the business concept was understood and managed with a high level of skill. Typically the point of departure for this strategy was to educate and develop the skills of the human resources appropriately and to create a business environment that made it attractive for multi-nationals to base a significant part of their global manufacturing capacity in the country. Being a technology colony per excellence is therefore a viable, and even a lucrative business strategy, even though it does have aspects of high risk, e.g. when other countries develop similar capabilities or when one "client" becomes a dominant part of the national business, such as hard disk technology in the case of Singapore. For the purpose of this discussion, a technology colony that derives its competitive advantage mainly from human resource productivity, will be referred to as a *technology colony of the first kind*.

Gaining technological independence:

Although no country in the world is technologically self sufficient, typical technology colonies would have to industrialise to some extent, simply to achieve levels of growth that would provide for their growing populations. While marketing and selling the productive capability of a country can provide sustained growth over a number of decades, each colony has to arrive at the point where it wants to have a larger share in the determination of its economic future. Recent examples are Taiwan in Personal Computers (PCs) and South Korea in vehicles and consumer electronics (just to cite some illustrative cases), where many companies started to develop their own design capability in order to compete globally in their own right and under their own brand names. This could be termed lateral innovation, in the sense that these companies did not, in a significant way, move away from their product ranges. They simply gained some independence by adding value at earlier stages of the product life cycle

THE TECHNOLOGY COLONY WITH ABUNDANT NATURAL RESOURCES

Three features:

One of the major historic reasons for the acquisition of colonies was to gain and secure access to natural resources. It therefore became a feature of most colonies that their industrial growth would evolve around the mining and/or the agricultural industries,

and that the location of these natural resources would form the nodes that would determine the development of the country's infrastructure of roads, railways, communication networks, power distribution and so on. A second feature would be the predominance of nationals from the former colonial power in the financial and industrial sectors of the colony. Third, as an evolutionary feature, secondary industries to cater for consumer goods and other consumables would be established, either as independent local businesses or as subsidiaries of foreign companies - again with a preponderance of ownership in the direction of the former colonial power. That these features together form an almost insurmountable barrier to real industrial development and growth, could be explained as follows:

- the business orientation of those "foreigners" (foreign in culture rather than in citizenship) that are involved in the industry of the (now technology) colony, reflect their training and their organisational loyalties. Stated differently, the managers and engineers involved in mining operations have little if any knowledge of the secondary industries that utilise the raw materials that they produce, and should they be so bold a to venture into forward integration, they would become the competition of their present, mostly overseas, clients. So they would not only face the displeasure of their present customers, but also have to move smartly into foreign markets where they are enthusiastic amateurs at best. They therefore tend to "stick to their knitting" and are rewarded by their (foreign) shareholders for doing so.
- the business orientation of the natives (native in terms of mind set rather than of descent) of the colony is formed by their careers and experience as employees in either the primary industries or infra structural enterprises, delivering utilities to industry or forming part of government organisations that provide regulatory services. They therefore have rather limited opportunity to gain training and experience in research, design and development environments, meet with entrepreneurs in technology-based ventures, or become familiar with a wide range of technological activities that do not form part of the local technology base. Neither their experience and training nor their environment, therefore shape them into entrepreneurs for establishing new, local, technology-based enterprises.
- the teachers and professors at the local tertiary education institutions are either educated in First World countries, or teach from First World textbooks, or both. The fact that such material is rather inappropriate for the colony is overshadowed by the perception that any other material would be inferior and would lead to colonial qualifications not being recognised by foreign universities or employers [1]. This aspect is expanded upon later on.

The net effect of these factors is to perpetuate the industrial profile of the colony as that of a primary product supplier to industrialised countries. Again, being *a technology colony of the "second kind"*, i.e. a commodity provider, is not necessarily an economic disaster, as the bank accounts of the Middle Eastern oil producing countries demonstrate, but then there are also the many countries that had to face the radical decline in the price of their limited spectrum of export products such cocoa, rubber, sugar, copper and so on. There are therefore two compelling reasons for the technology colony of the second kind to escape from that status, i.e. the declining value of primary products and the fact that many of these resources are of a finite quantity. So when the oil wells eventually run dry, the Arabian countries should have something in place to sustain their economies, and countries like South Africa should be prepared to cope with the loss in value of gold, diamonds and all the other minerals that were the traditional providers of economic welfare.

Unique problem:

From the foregoing it is clear that technology colonies of both kinds have compelling reasons to diminish their colonial status, and that, even though the generic strategy of moving "upstream" in the product life cycle seems to be similar, the more detailed approach between them differs in essential ways. Whereas the colony of the first kind has a "singular" option and the way to execute it successfully has been developed to a large extent, the colony of the second kind has to follow a more complex strategy, if it is to utilise the potential of its natural resources to enhance the scope and rate of its industrial growth. The insight that this is not a trivial problem, is supported by the observations by Peter Drucker [2] about the chances of developing countries to industrialise successfully.

MANAGING THE COLONIAL STATUS

As indicated before, one generic element of the strategy for both kinds of technology colony, is to "integrate backwards" along the product life cycle, thereby adding value at earlier stages of the life cycle and gaining ownership of intellectual property (IP), that in turn provides the freedom to export. This is illustrated graphically in Fig. 2. Fig. 2 indicates that technology transfer at the production and trade in final products end of the life cycle should be decreased in relative terms, while more technology should be transferred in the form of design and development capability, applied research capability and eventually, basic scientific research capability.

It seems to be almost a logical process that "backward integration" should proceed from the later to the earlier phases of the life cycle, because it reflects the evolution of the engineering and technical skills base in developing countries. Japan and her Pacific Rim followers have demonstrated this process over many years and over a wide range of technological disciplines. What these countries failed to do however, was to write a textbook on the finer details of how to do this successfully, in order to assist other developing countries, and particularly the Third World ones.

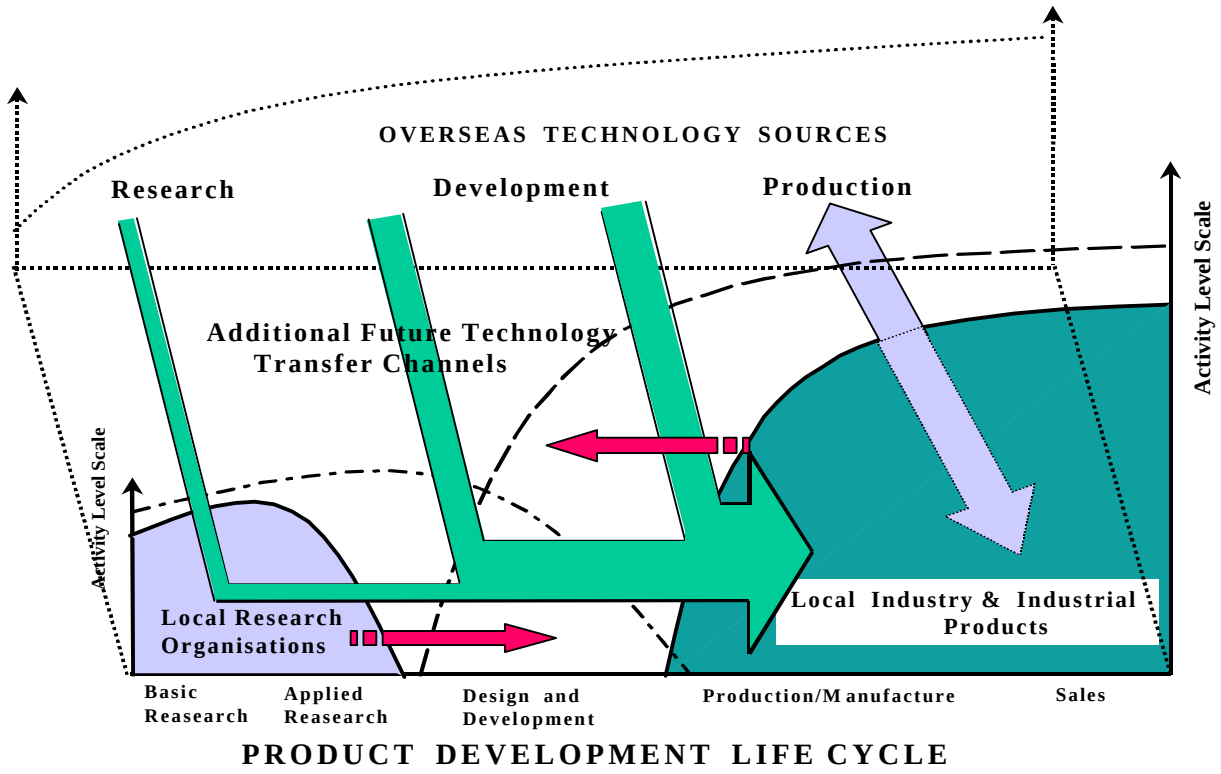

Figure 2: The effect on technology flows resulting from "backward integration"

While this is clearly a facetious statement, the intention here is to emphasise that simple logical considerations are often overlooked when colonies (or enterprises in colonies) go about technology acquisition and transfer exercises and they fail to ensure that all the elements of the transfer process are in place. Much of the lament about failed development projects of the World Bank and other development organisations in Africa, arises from the problem of limiting the scope of technology transfer projects, simply because no individual project could afford to "fix" the national contextual problem in a particular country. What normally comes to mind here is the absence of essential elements of infrastructure, but what is often overlooked is the availability of the scientific and technological skills base to ensure the sustenance and growth of the technological "implant". The effort to keep the implant alive while other elements of an embryonic, viable technological community are established, necessitates long term staying power of 10 to 20 year horizons - something foreign-based organisations find difficult to achieve. Furthermore, entrepreneurs in the colony may, at best be ignored by foreign-owned, local industries, but they could well face some very negative action if they are identified as future competition to these companies. This is clearly an issue that goes beyond the private sector only, making the participation of the local government an essential part of success. Consequently the conclusion can be made that the "management" of the technological evolution of the technology colony, has to be (primarily) a joint effort between local enterprises/entrepreneurs and government. This does not mean that multi-national corporations would not participate in these efforts - many examples could be cited where they were actively involved in helping the colony on its way to greater maturity, but it must be understood that they are not necessarily concerned.

STRATEGIC CONSIDERATION FOR THE NATURAL RESOURCE RICH COLONY

Rather than to dwell in too much detail on the strategic alternatives that are common to the colonies of both kinds, the rest of the discussion focuses on the natural resource rich country. The reasoning behind this is threefold: first, technology colonies of the first kind seem to have had a much higher level of success than the others, and may therefore have less need of another discussion on their particular problems; second, technology colonies of the second kind have to deal with a wider scope of alternatives and third, the author is familiar with the particular case of South Africa, that seems to contain a number of features that may be of interest to other, similar countries.

Strategy 1: Backward integration

This strategy is as discussed in the forgoing section, with some qualification, to the extent that the products/processes selected for gaining "design ownership" may depend on the nature and quantity of natural resources available, e.g. where there is an abundant supply of coal, there would be good reasons to consider going into (hydro-carbon) chemicals and chemical products.

Strategy 2: Beneficiation

Beneficiation refers to the concept of adding value to raw materials. Broadly speaking it is aimed at gaining economic advantage by increasing the value of primary products before exporting these at world commodity market prices. Thus a ton of rolled steel plate is at least 5 times the value of a ton of iron ore, a ton of pressed motor car body panels is worth much more than a ton of rolled steel, and so on. Typically 5 levels of value addition are used to indicate different levels of beneficiation, i.e.

- primary products: agricultural products, mined ores, coal, etc.
- secondary products: spun wool, wine, steel sections, cement, etc.
- material intensive products: steel structures, motor cars, white goods, etc.
- capital products: machine tools, chemical reactors, etc.
- specialised products: medical equipment, computers, defence systems, space systems, etc.

Even though the concept of beneficiation makes eminent sense, people are often puzzled by the fact that it does not happen almost automatically in developing countries. A few of the key reasons for this can be recognised to be, first that the margin on conducting a business at the "lower" level of beneficiation may be higher than at the next level. An example would be that the profit on selling iron ore could be double that of selling steel sections. This would hardly be an incentive for an iron ore mining company to move into the steel making business. Second, the scope of skill/knowledge of the key technologists and managers. This was referred to before, indicating that mining engineers may not feel confident to tackle secondary processing, and steel makers would find it extremely difficult to enter the motor car design and development arena. Third, there is the indirect reward phenomenon. This refers to the benefit derived by the national economy if an individual enterprise exports products - the contribution to economical growth and improvement of the balance of payments accrues at national level. At the level of the exporting company, there is the benefit of a larger market than the domestic one only, but the profit margin on exports may even be thinner than that on local sales. Governments therefore often find it beneficial to run some or other export incentive scheme, where at least part of the national benefit is handed back to the exporter.

Strategy 3: Solving local problems.

Quite often it is found that by solving particular problems in a country, products are created that make sense in other, "similar" countries, and thus a serendipitous export advantage is created. An example is the prepaid electricity meter that was developed in South Africa to provide electricity to disadvantaged communities. Even though the concept of prepaid meters has been around for a long time, the particular design to make it tamper proof, has made it an export product going to a number of other African countries, as well as South America.

Strategy 4: Clustering

Ever since the notion of industrial clusters had been articulated, technology colonies have had a powerful concept to work with. This could be illustrated by the evolution of the industries that were established to serve the mining community in South Africa. These industries expanded their product portfolios in many directions, such as the vehicle component industry, agricultural processing equipment and so on, until today some of these enterprises derive most of their income from exports of reasonably sophisticated components and subsystems.

Strategy 5: White Space initiatives

The term White Spaces is used here to indicate the exploration of opportunities to establish new ventures in areas where no businesses existed in the country before, such as aerospace products, information technology, pharmaceuticals, defence technologies and so on. Clearly here the government may provide incentives and become the first major client, to ensure that such a new industry becomes viable. Such initiatives should be undertaken within the context of some national strategy, where government and private investors would join forces to achieve some future strategic goal.

GRAND STRATEGY

Technology colonies of the second kind have to be skilled in weaving a complex portfolio of strategies over time to optimise the net result of their resource investment. They have to understand the advantages and disadvantages of each of the strategies outlined in the previous section and decide on the extent to which these will be deployed in combination or in sequence. While they are not excluded from the primary strategy of technology colonies of the first kind, i.e. the enhancement of the skills base of their human resources, they may find that the human resource base with the appropriate potential, may be rather limited in the short term. Similarly the strategy of solving local problems is somewhat akin to radical innovation - while it often brings a large quantum of benefit, it is extremely difficult to manage, both in time and in content. The strategy of beneficiation may indicate the goals of advancing one or more steps along the 5-level scale,

but a significant opportunity may lie in the manufacture of high grade materials, forming the inputs to semiconductor manufacture, the pharmaceutical industries, etc.

It is clear that the development of an optimal strategy is a complex task - not necessarily more complex than that in a developed country, but certainly one that is less comprehensively supported by robust theory and practice, and one that often has to take place under the burden of severe political pressures. Three elements of the National Innovation System (NIS) of technology colonies seem to be of cardinal importance for the achievement of sustained growth away from the dependence status, i.e.

- the reorientation of the tertiary engineering educator community. This refers particularly to the "automatic" assumption that the syllabi taught at First World institutions are the "correct" ones for the colony. Some examples from the university education of engineers could illustrate the principle: in South Africa hardly more than 10% of engineering graduates enter into employment situations where design and development are the focus of the enterprise - the majority go into maintenance, operations and project management. Yet the under-graduate engineering curriculum is poor in subjects such as statistics, reliability engineering and project management, and the word maintenance management is reserved for post-graduate short courses. No South African engineer would start the design of a product with the explicit assumption that it should require zero maintenance or, at worst, require only operator level maintenance. Yet we are all fully aware that there are hardly any skilled technicians in most parts of Africa, that forms at least our most obvious market. We do not know how to approach such problems, because our textbooks do not address these issues.
- the role and functions of scientific institutions need to be revised and adapted. In the technology colony these institutions may be limited to R&D capabilities at universities, but in many cases some separate institutions are present to serve at least some segments of government, e.g. environmental control, building regulations, health services, etc. In most British colonies, so called *Science Councils* were established. These are still around in countries in Africa, India, Australia, etc., albeit in somewhat different evolutionary forms compared to their almost identical original formats. While the CSIR in South Africa was referred to as a university without students in the past, it has evolved to what is now called an "ITRI", or an industrial technology research institute. Fundacion Chile is often cited as an "ideal" ITRI model. The main role of an ITRI is seen to be the development and transfer of technology to industry to achieve economic growth. In this role it is an essential part of the NIS, rather than a status symbol that local government officials show to visiting foreign dignitaries. Status symbol R&D institutions, also referred to as scientific zoos, are at the mercy of government bureaucrats for their existence - since they are not seen to be of value to local industry, they have no stakeholders to protect them from budgetary manipulation. While an ITRI should focus on the provision of technology relevant to the industrial strategy of the country, it should not be prevented artificially from wandering into "white space technologies" as well, because it is quite often here where radical benefits may be obtained.
- the approach to the management of the NIS should be formalised and placed under constant review for improvement. The articulation of the concept of the national "system" of innovation is relatively recent [3], but the debate about "central planning" is an old one. Many developed countries, such as Germany and Japan, have succeeded in creating management systems that do not even try to do central planning, yet they do achieve high levels of synergy between the elements of the NIS, leading to significant competitive advantage. Developing countries are often given foreign aid, aimed at operational goals, such as water supplies, elements of infrastructure, etc., but very seldom to build national management capability. The recent examples of activities in South Africa, supported by donors such as Japan, Canada, Germany and the UK must therefore be commended as a new and most appropriate trend in international co-operation. In contrast, the co-operative programme of the member states of SADC (Southern African Development Community) contains very little in the way of national management capacity building.

CONCLUSION

Being a technology colony is neither something to be ashamed of, nor necessarily a disaster. Remaining one, should not be a fate to be suffered, but an opportunity to be managed. Non-technical managers are poorly qualified to understand the strategic alternatives that need to be considered when either national or corporate management has to decide on the way forward. Therefore those skilled in the management of technology should play their part in creating the best possible growth trajectories for their economies. That this is not a simple task, should no longer be a matter of dispute. What may be open for alternate views, are the ways and means by which the colonial mindset in so many role players in the technology colony, could be shifted towards an understanding of the extent to which they have been conditioned to see the world in a certain way, and a confidence that they may become much more of masters of their own destiny.

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