Systems of innovation, Competitiveness and Natural Resources in Africa

Lynn K. Mytelka
Banji Oyelaran-Oyeyinka

UNU/INTECH

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1.0 Introduction

Three major changes in the pattern of production and in the nature of competition have altered the competitive environment for firms in both developed and developing countries. These have particular significance for competitiveness in natural resource based sectors.

Since the 1970s, production has become increasingly more knowledge-intensive as investments in intangibles such as R&D, software, design, engineering, training, marketing and management have come to play a greater role in the production of goods and services. Much of this involves tacit rather than codified knowledge and mastery requires a conscious effort at learning by doing, by using and by interacting

Gradually the knowledge-intensity of production extended beyond the so-called high technology sectors to reshape a broad spectrum of traditional industries from the shrimp and salmon fisheries in the Philippines, Norway and Chile, the forestry and flower enterprises in Kenya and Colombia, to the furniture, textile and clothing firms of Denmark, Italy, Taiwan and Thailand. Indeed where linkages were established to a wider set of knowledge inputs and the local knowledge base was deepened to include scientific and engineering skills, design, search and quality control capabilities, these traditional industries have shown a remarkable robustness in the growth of output and exports. Most developing countries have not kept up in building these knowledge-based capabilities and this is particularly true for countries in Africa.

Within the context of more-knowledge-intensive production, firms began to compete not only on price but also on the basis of their ability to innovate. The entrenchment of an innovation-based mode of competition has increased the speed with which new products are developed and moved to market. This, coupled with rising levels of productivity and quality improvements in commodity-based industries has given rise to the need for continuous innovation across all industries. As a result, competitiveness can no longer be based on static comparative advantage.

Nor can tariffs protect inefficient local industries. Liberalization and deregulation of domestic markets has accelerated the pace at which innovation-based competition has diffused worldwide, drawing further attention to the need for learning and innovation even in the so-called 'traditional' or 'commodity-based' sectors. New types of policies will be required to meet these challenges. It is in this context that conventional views on innovation in developing countries must be rethought and new concepts that embody dynamic change, such as the notion of an 'innovation system' must be introduced into policymaking.

Among the more common beliefs still encountered in discussions of innovation systems, for example, is the notion that innovation is something that only takes place in countries like Japan or the United States, in large multinational corporations or in what are regarded as the high tech industries. Indeed, much of the conventional literature continues to associate innovation with the kind of activity by firms that takes place at the technological frontier or what Schumpeter has called invention. A narrow definition that equates innovation with invention of this sort, however, denies the importance of

- building upon indigenous knowledge,
- exercising creativity in the development of new products, processes, management routines or organizational structures that correspond to local conditions and needs,
- creating the local linkages that support the modification of production processes to bring costs down, increase efficiency and ensure environmental sustainability and
- mastering imported technology in order to transform it in new ways and
- developing policies that stimulate and support a continuous process of learning and innovation..

In what follows, therefore, we regard innovation as "... the process by which firms master and implement the design and production of goods and services that are new to them, irrespective of whether or not they are new to their competitors — domestic or foreign." (Ernst, Mytelka & Ganiatsos:1998, pp.12-13). By adopting a broader definition of innovation, we can more easily identify opportunities for learning and innovation in small and medium-sized enterprises (SMEs) and in 'traditional' 'commodity-based' industries than has been the case in the past. By reconceptualizing traditional commodity-based 'sectors' as 'innovation systems', the configuration of critical actors in such a system, their habits and practices with respect to innovation, their level of competence and the nature of their interactions emerge more clearly and can more easily be targeted through policy. The innovation system approach thus has direct utility for policymakers, as we shall show.

It is fortunate that in a number of sectors across the developing world the process of transformation into innovation systems has already begun. In this paper, we draw on these to illustrate the principles behind this 'innovation system' approach in three distinct non-fuel commodity product (NFCP) groups of special importance in Africa: food & beverages, agricultural raw materials and non-fuel mineral. In each of these, global competition has intensified in rapid and surprising fashion. In section two of this paper, we briefly examine the historically poor returns to natural resource based industries in Africa and the role that weak domestic linkages and limited development of the knowledge base are believed to have played in this process. Section three presents the innovation system approach and Section Four applies it to examples of how traditional sectors are being transformed into dynamic systems which have the potential for a more positive impact on growth and incomes in developing countries. The concluding section outlines suggestions for theory and policy.

2.0 Reaping Greater Rewards from Africa's Natural Resources

Africa has abundant agricultural, aquatic and mineral resources upon which its economies have traditionally depended to finance imports. These sectors remain the backbone of Africa's productive structure. Much of the labour force, located largely in rural areas, derives its livelihood from these natural resource sectors, in particular, agricultural production including the export of fish and forestry products. Paradoxically, the mining and petroleum exploration activities exist side by side with the farming and fishing communities but have little to share. To the contrary, the presence of the former has been damaging to the latter[1].

Since the 1960s, African governments have sought to build an industrial sector but local entrepreneurs were lacking, and technical and managerial skills had to be developed concurrently. Manufacturing Value Added (MVA) as a share of GDP was a modest 4% for SSA, through the 1960s and 1970s; industrial infrastructure was weak, while industrial production was largely in the consumer goods sector, (UNCTAD, 1998). Foreign Direct Investment was limited in most cases to the extractive industries, notably mining (iron ore, bauxite, and petroleum among others). These industries have remained largely enclave sectors, in some cases, however, employing state-of-the art technologies, and attracting the most competent and skilled local labour.[2] Recent research in the case of Africa suggests that the skill-, technology- and capital intensity of the mining sector has resulted in the diversion of substantial human and financial resources into a sector that is only weakly linked to the national system of innovation and production. (Wood and Berge, 1997; World Bank, 1998). Cost overruns and delays that result from the poor planning and execution of large scale projects contributes to the limited returns from extractive industries.

Though much of the mining sector's output was exported, forward processing of natural resources in Africa, historically was a difficult proposition since the decision as to where such activities would be located lay with foreign owners whose global interests took precedence over those of the local economy. Nationalization was of little help here, as African countries lacked the capital to enter into the extractive industries and more importantly, rarely had the managerial, marketing and engineering capabilities to take advantage of ownership change (Adei:1987). Tariff peaks[3] further discouraged local processing activities.

In spite of the continent's considerable resource abundance, the region's per capita income remains the lowest, even though global demand for Africa's resources remains high. A number of factors are believed to account for the poor returns to natural resource production. First, fluctuating terms of trade for non-fuel commodities as well as steep variations in export prices make planning and investment in these industries difficult. Increased competition, coupled with price inelastic demand in such commodities renders even more fragile the economic base in African economies. This is particularly evident in economies that are heavily dependent upon a single agricultural export crop. Coffee economies, such as those in Uganda, Burundi, Ethiopia and Rwanda which depend upon coffee for between 60-80% of exports, are particularly vulnerable

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[1] Conflicts, for example, have grown between multinational oil companies drilling petroleum in Nigeria's Niger Delta and the local farming and fishing communities as a result of the environmental degradation resulting from huge oil spills, and the subsequent destruction of farming and fishing in the area. The hanging of the environmental champion of the Ogonis in the Niger Delta, the writer, Ken Saro-Wiwa , is a direct fall-out of this phenomenon of "arms-length" co-existence of resource wealth and human squalor.

[2] The petroleum upstream sector is one such example because it utilizes advanced information technologies to map remote oil locations off and on shore. In most of the countries skills are initially brought in from abroad in all facets of operations and in a few cases, such as the Nigerian oil sector, local skills have gradually taken over, particularly in downstream petroleum refining..

[3] Tariff peaks are constituted by the jump in tariff rates on processed raw materials products over those exported in an unprocessed state.

(Fitter & Kaplinsky: 2001). With rare exceptions[4], African countries exhibiting high dependence on coffee have the lowest GNP/capita.

Second, while resource endowments have been the starting point for the industrialization of a number of developed countries such as Australia and the United States, recent studies have found a negative relationship between per capita growth rates and the ratio of natural resource exports to GDP for a number of developing countries, (Sachs and Warner, 1995). Mineral exporting countries are a case in point. In a study of twenty-three mineral exporters in the 1980-1992 period, the average per capita growth rate was a negative 0.5%. Only five countries: Indonesia, Colombia, Chile, Oman and Botswana recorded positive per capita growth rates. For all the countries, the average rate of GNP growth was 0.9%. Apart from the negative growth bias, mineral exporters also fare poorly in terms of social welfare, and income inequality, (Mikesell, 1997; Aunty, 1998). These relationships tend to hold even in periods of high export earnings.

Several explanations have been offered for the poor returns to natural resource abundance, particularly in the extractive industries. One of these, is the so-called "Dutch Disease"[5] which results from booming mineral exports that generate substantial rents. This, it is argued, leads to a rise in value of the local currency but also diversion of investment from, and decline in competitiveness of, non-mineral sectors. Management of the export windfall also contributes to corruption, while the benefits are often transitory.

Another explanation has come to be known as the "resource curse". This explanation stresses that resource-based industries have lower employment-intensity than manufacturing industries but higher skill intensity[6]. One might expect, therefore, that such industries would contribute to higher incomes. Resource-rich countries such as those in Sub-Saharan Africa, which have the highest ratio of primary exports to, manufactured exports, however, have the lowest per capital income. In contrast, resource-poor East Asian countries have relatively higher per capital income, higher ratios of manufactured exports. They also have higher ratios of schooling. The lesson to be drawn from the above is that both comparative advantage and positive returns to growth from natural resource industries might only be possible if resource-rich countries complement their resource abundance with higher skills and technical competencies and stronger local linkages. Such skills and linkages will differ across specific innovation systems. Policies, therefore, cannot be generalized in their entirety but must be tailored to these local and sectoral innovation systems

For policies that will enable African countries to realize greater returns from resource abundance to emerge, a reconceptualization of the role of resources, not only in growth

[4] With its far more diversified economy, the Cote d'Ivoire is an exception.

[5] The phenomenon was first mentioned with the discovery of natural gas and the prosperity that followed in the Netherlands in the 1960s.

[6] For instance, a one million ton per annum Blast Furnace/Basic Oxygen Process (BF/BOF) plant requires at full capacity, about 10,000 staff of different disciplines in science, engineering, and technical skills levels. In the acquisition of integrated steel technology in Nigeria, hundreds of engineers in metallurgy, mining, mechanical, chemical engineering among other disciplines were trained in the Soviet Union, India and Germany. In the end the plants remain uncompleted and inoperable due to funding difficulties and most of the staff were lost to other sectors of the economy. One of the two integrated steel plants, the Delta Steel Company, a one million ton Direct Reduction/Basic Oxygen Furnace (DR/BOF) process, cost $2 billion when it was completed in 1982, see full details in (Oyelaran-Oyeyinka, 1994).

but in sustainable development[7] , is called for. This rethinking, we believe, will involve a shift away from a narrow focus on the 'level of growth' to one on the "structure and form" through which growth can be achieved; from exclusive "reliance on imported technology to the building of indigenous technological capabilities", from "a view of the rural sector in terms of its extractive potential to one which stresses its importance as a market for domestic manufactures" and a source of inputs for forward linking activities and; from mass production to more flexible, geographically decentralized, networked forms of production that interface larger and smaller firms, science-based and indigenous knowledge (Mytelka:1980). These changes can be summed up as the reconceptualization of natural resource sectors in systemic terms.

3.0 From Sectors to Innovation Systems[8]

A system of innovation consists of a network of economic agents together with the institutions and policies that influence their innovative behaviour and performance (Nelson:1993; Lundvall,1992). As a conceptual framework it refers to a new understanding of innovation as an interactive process in which enterprises in interaction with each other and supported by institutions[9] and organizations such as industry associations, R&D, innovation and productivity centres, standard setting bodies, universities and vocational training centres, information gathering and analysis services and banking and other financing mechanisms play a key role in bringing new products, new processes and new forms of organization into economic use (Figure One).

From a policy perspective the innovation system approach draws attention to the behavior of local actors with respect to three key elements in the innovation process: linkage, investment and learning. Such an approach is particularly useful, as overtime, policies and routine interactions lead actors to develop a set of habits and practices with respect to innovation (Freeman: 1988; Mytelka:1999)10. The impact of policies can be expected to differ depending upon the policy dynamics that result from the interaction between policies and these traditional habits and practices. Policy dynamics will thus affect the extent to which existing habits and practices are reinforced or changed. This is especially relevant in the application of a national innovation system approach in developing countries.

[7] Sustainable development is understood here in economic, social and environmental terms.

[8] This section draws on Mytelka (2000) and Mytelka & Farinelli (2000).

[9] Formal definitions of 'institutions' stress the "persistent and connected set of rules, formal and informal, that prescribe behavioral roles, constrain activity and shape expectations...they...give order to expectations and allow actors to coordinate under conditions of uncertainty." Storper,1998, .24. See also Edquist & Johnson: 1997.

[10] In the case of Japan, the set of habits and practices that induced learning to learn in that system developed as "Japanese management, engineers and workers grew accustomed to thinking of the entire production process as a system and of thinking in an integrated way about product design and process design". This enabled them to redesign an entire production system for quality, productivity and a cost-effective process of continuous innovation (Freeman:1988,335).

Figure One

Innovation Systems

Source: Mytelka : 2000b,17.

Innovation systems can be conceptualized in geographical or sectoral terms. At the national level, for example, certain types of actors are common across all national systems of innovation, though they might not perform equally well – educational institutions and banks are two such types of actors. In sectoral terms, the configuration of critical actors will vary from sector to sector. Standard-setting bodies, vocational training institutions, molecular-biology laboratories and design centres will not all be equally important in systems as diverse as biopharmaceuticals, fish farming or mining.

Identifying the critical actors in the system, their traditional habits and practices with respect to innovation, investment and linkages, their level of competences and the nature and intensity of their interactions will require a systematic analysis of the local system and a broad comparative analysis of similar systems across a variety of historically shaped contexts. This can be done for any potential innovation system. In what follows we briefly sketch out a methodology for analysis, focusing in particular on the four key elements identified above. Each of these can be operationalized through a number of indicators

- An optimal **configuration of actors** in a system, identified critical actors with reference to a dual context: the local and the global. In analyzing the presence of critical actors within the innovation system, the concept of 'critical' is thus understood to be a function of both the techno-industrial base of the firms within local system and the global techno-industrial system in which these firms are also embedded. The latter provides a mapping of the 'knowledge' bases that are required for innovation in a globalized industry. The configuration of critical actors can thus be expected to vary across techno-industrial systems.

- **Actor competence** is broadly defined to include production and management skills & capabilities as well as technological sophistication. The higher the level of competence, the greater the probability that financial and human resources can be found to recombine knowledge bases in new and innovative ways.

- This must be tempered, however, by the **traditional habits and practices of these actors** with respect to the three pillars upon which an innovation process is based: learning, investment and linkages. The ability to learn, to invest and to partner increase the likelihood that critical actors in the system will move to assume new roles and develop new institutions in response to changes in competitive conditions. In some instances the level of trust is too low to envisage cooperative interactions. Policies and programs can stimulate and support a process of change provided that their design takes these habits and practices into consideration.

- In the innovation literature, the **nature and extensiveness of interactions** amongst critical actors in a system take on particular significance. In the context of sector-based clusters built around the value chain, relationships between actors have tended to consist mainly in the unidirectional transfer of information from a client to its suppliers. Two-way partnerships were a rarity. In many cases, traditional habits and practices do not predispose actors to a more innovation-oriented form of interaction in which knowledge is shared and learning maximized. The way in which competition among firms takes place is also a critical element in determining the dynamics of growth in a geographically based cluster[11]. Where competition is based on price and wage reductions rather than on quality, technological upgrading and product innovation, cooperative relationships are rendered more difficult.

Underlying the 'system of innovation' approach is a resurgence of interest in innovation and a reconceptualisation of the firm as a learning organization embedded within a broader institutional context (Nelson and Winter, 1982; Freeman, 1988; Freeman and Perez, 1988; Lundvall, 1988). That context is preeminently national and domestic policies have conventionally been viewed as a critical means to orient the behavior of

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[11] See Pyke & Senenberger (1992) for a more extensive discussion of this point.

national actors towards innovation. Today, however, the institutional set-up at the global level has become a powerful force that shapes the parameters within which actors make critical decision with respect to innovation. As Figure One illustrates, these include the profound shaping effects of transnational corporations on the structure of markets and the pace and direction of technological change as well as the set of international agreements dealing with trade, investment and intellectual property.

The failure to deal with the global in the context of national systems of innovation has led many to believe that national governments and within nation-states, provincial and municipal governments have only a limited role to play in fostering dynamic innovation systems. This, however, is not the case. Domestic policies can matter and international institutions are not immutable. Nonetheless, it is important to understand the constraints and opportunities posed by international regimes and by the structure of global industries and the strategies of actors within them as policies are designed at home.

The global also has profound implications for the local at the level of industrial sectors where the tendency has been to identify innovation systems with clusters formed by actors along the value chain. South Africa, for example, applies the cluster concept to the wheat-miller-bakery chain within the food industry and to the links between auto parts manufacturers and assemblers. This approach, while useful in identifying traditional backward and forward linkages, generates a static bias since the cluster is defined in terms of the standard industrial classification. Its boundaries are thus fixed and the actors are configured in relation to existing production processes and products. Thus value chain based approaches such as these cannot capture situations in which industrial boundaries are blurring and knowledge bases that have been developed for one purpose can be turned usefully to another. (Delapierre & Mytelka:1998, Mytelka & Delapierre:1999).

Not all clusters, moreover, are innovation systems. Many are stagnating or in decline as competitive conditions around them change. Somewhat counter-intuitively, however, a number of clusters in the developed world, centered on traditional 'commodity-based' industries, have successfully undergone such a transformation in the 1970s and 1980s. Some of these, the woolen textile industry in Italy, the food industry in Norway (Smith:1999,10,19), forestry-related industries in Finland (Pajarinen, Rouvinen and Yla-Anttila: 1998) or the furniture industry in Denmark (Maskell & Malmberg:1999), for example, continued to expand output and exports over the 1990s despite rising levels of competition globally (Mytelka & Farinelli:2000). So, too, have a number of sectoral clusters in the developing world.

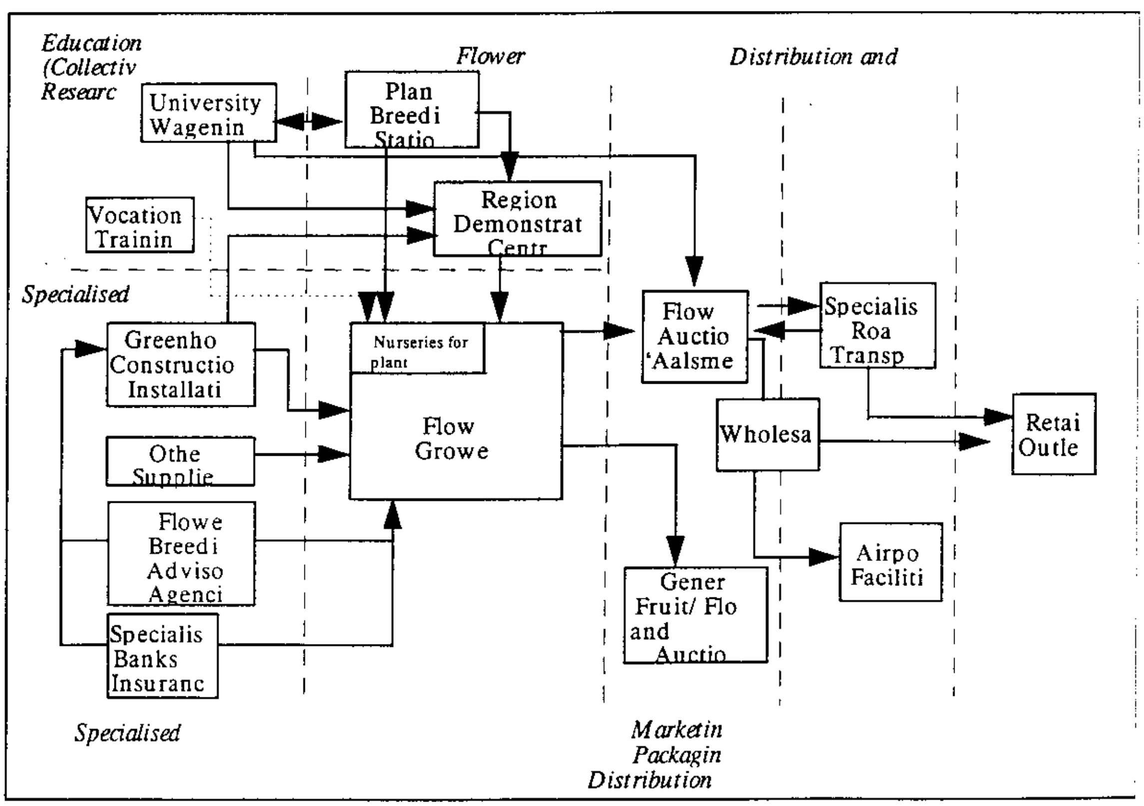
4.0 Innovation Systems in Commodity-based Industries

The transformation of traditional commodity-based sectors into innovation systems is underway in a number of developing countries. We illustrate this here with short case studies of emerging innovation systems in the production and export of cut flowers, mineral processing and food and beverages.

Cut Flower Exports

Flowers, and especially tulips, are a trademark of the Netherlands but their continued production in and export from that country in the face of rising competition elsewhere has required a thorough reconceptualization of this traditional product and the system within which it is produced[12]. From a standard commodity, flowers have emerged in designer hues, a multitude of colors and a variety of shapes and forms to suit a vast range of consumer tastes. Links to plant breeders, to university researchers and to specialized agricultural suppliers, demonstration, finance, training and advisory services, within the national innovation system have all become necessary. Reaching markets around the world has also required new skills and linkages to distributors and transporters. At a still deeper level, modern cut flower production interact widely with other knowledge bases in the national system including water, climate, and engineering subsystems. National knowledge bases such as the Netherlands Organization for Industrial Applied Research do the certification of the products. It has contract agreements to test new designs and develop Computer Aided Design (CAD) systems. The Centre for Agricultural Research, a publicly funded agency, conducts and disseminates research results in greenhouse construction. The Dutch cut flower industry thus illustrates the ways in which a traditional sector can be transformed using new knowledge bases. The industry is the most competitive in the Netherlands with a global market share of 65 percent. The industry originated from traditional agriculture and horticulture but, as Figure 2 illustrates, there has been a co-evolution of traditional and modern knowledge bases and a transformation in traditional habits, practices and designs.

Figure 2 Flower cluster in the



Source: Boekholt:2001

[12] See Boekholt, 2001 ?

In the developing world ,Colombia was the pioneer in cut flower exports. In the 1960s a largely cattle producing region began its transformation through the entrepreneurship of two American academics[13]. Production of cut flowers grew dramatically in the 1980s and by 1995 some 500 firms were cultivating 4,5000 hectars of cut flowers in greenhouses in that country and the industry has become an important regional employer, generating some 75,000 'direct' and 50,000 'indirect' jobs. It is the second largest agricultural exporter after Bananas and the second largest in international terms as well (after the Netherlands). Most of Colombia's cut flowers are exported to the United States.

New actors and new linkages have been critical elements in the creation of an innovation system. So, too, have new policies and support structures. Local growers, a large percentage of whom are women, market through Colombian registered companies. Training through SENA and research, through the national agricultural institute, CORPOICA have supported the transformation. Over time and perhaps even more critical in this particular system were the new roles assumed by ASOCOFLORES, the Colombia Association of Flower Exporters, a private association with membership of 222 farms accounting for 80% of total exports. In addition to its traditional role as a defender of its member's interests, ASOCOFLORES promotes scientific research and human resources development, and provides economic and technical information to its members. Conceived within a broad innovation systems framework, the association also provides: support in environmental and hazard management; integrated pest management and disease research (with a focus on replacing pesticides with biological substitutes); The need for continuous innovation led the association to create and fund its own research facility, the Center for Agro-industrial and Extension (CIIA), in collaboration with the University of Bogota, and the Catholic University of Leuven in Belgium. The CIIA is engaged in training and extension services, and a small research station just outside of Bogota where research into new improved types of greenhouses and soil analysis is underway. As it has evolved, its linkage to farmers and its ability to respond to inquiring emanating directly from them has developed. Export success was facilitated by the active supporting roles of the many actors in the system both private and public.

Windows of opportunity for engaging in a 'non-traditional commodity activity' and to catch up in the production and export of cut flowers are also opening for most African countries with the right climatic conditions. As in Colombia, the initiative in Uganda started small. Five private firms invested in the farming of roses with a loan from the Africa Project Development Facility (APDF). The loan was used to conduct a feasibility study and to hire a foreign consultant. Abundant rainfall and the warm climate of Lake Victoria are particularly suited to rose farming. The entrepreneurs opted for the high-grade roses, the tea hybrid, and the long stem big flower head variety, a product targeted to the Dutch auctions in Amsterdam where it fetches the highest prices. In time, however, temperature in the Victoria Lake region fell below sixteen degrees, the roses thus ripened earlier than in other growing regions and thereby failed to reach the head size and length of competing products from Northern Kenya and Tanzania (Arusha).

[13] The Colombian case is drawn from UNCTAD:1999,pp.43-44.

The roses had to be sold at a discount.[14] but an important learning process had taken place and to be fair to the farmers, the changing climatic conditions were a totally unexpected development. The farmers have turned their attention to the high-volume, low-margin market segment targeting retail shops and supermarkets in Europe, where quality requirements are less stringent. Although roses from Uganda have much lower prices compared with products from Tanzania, Kenya and Zambia, farmers were able to turn initial mistakes into profitable knowledge and experience through learning-by doing and through learning-by-hiring of consultants. Of critical importance then is the way in which knowledge was acquired and reused. From its difficult beginnings Uganda's cut flower production is now highly diversified with several varieties planted on 75 hectares. The tea hybrid and the sweetheart short stem-smaller head roses with which the farmers started constitute 50% of total production reflecting a mastery of the process of production and distribution. Exports grew from a mere $158,000 in 1993 to $2.8 million in 1996, with many more farmers joining in the cultivation of cut flowers.

Cut flower production in Ethiopia again illustrates the important role of private initiative within the national system of innovation.[15] The entrepreneur in question also started with a loan from local banks and with assistance from the Oromo regional government that made land available.[16] Production began with summer flowers, again as in the case of Uganda, with an eye to the Dutch flower market. The initial feasibility study was facilitated with a detailed geological and soil map of Ethiopia prepared by North Korean technical assistance during the Derg regime. The Agricultural Production Development Fund (APDF), a World Bank assisted organization based in Nairobi assisted the farm in employing the services of a well-known foreign consultant on Africa's cut flower. The consultant provided start-up expertise and subsequently visited the farm three to four times a year to monitor progress. The farm employed some 70 farm hands in 2000 supervised by a production manager, who is in turn supervised by a consultant hired from Nairobi on a two-year training contract. The plant uses drip irrigation and fertilizer where required including herbicides and pesticides. Cold storage is provided at the plant and in Addis Ababa, the point of loading for export. The estimated capacity of the plant was 500,000 stems per annum in 2000 at a wholesale price of 1DM for every three stems. In the beginning, the farm ran into competition with a large Dutch company in the market for summer flowers and was driven out of that market when the former lowered it prices. This early learning experience in strategic marketing was turned into an advantage as the entrepreneur shifted his production to the equally high value rose market in Germany. Fortuitously, the German carrier, Lufthansa flies direct to Nairobi in seven hours, and in partnership with a German marketing organization that offered to take as many roses as the farm produced, the farm shifted its focus to the German market.

While Kenya, Uganda and Ethiopia have made major strides in catching up, keeping up is far more difficult since the target is much closer, the speed at which innovation takes place becomes a factor and there is less time to put the package of components and skills together. It thus requires a more substantial science and technology infrastructure on which firms and farms can draw rapidly for new inputs, a strong production base to move down the cost curve quickly and the design and development capabilities to go

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[14] The Dutch auction that was the initial target charge 21 to 25 percent commission on gross sales but demand exacting quality standards which the Ugandan roses cannot match.

[15] The Ethiopian case is drawn from UNCTAD (2000)

[16] Securing adequate land for large-scale farming could be a major obstacle due to scarcity of fertile agricultural land in Ethiopia.

beyond imitation to the introduction of variety. Keeping up, moreover, is a continuous process predicated upon having sufficient financial resources to move products to the market early enough in the product cycle so as to capture market share and generate the revenue needed for investment in successive product generations. For these firms and others of their kind to continue to compete successfully in these highly lucrative but competitive markets, greater support will be required from the public sector and greater linkages will need to be forged with other actors in the national system of innovation. Finance, for example, is critical in responding to changing conditions. For instance, the Ethiopian cut flower farmer was promptly offered another credit by a local bank when it decided to opt out of the competitive Dutch market. This enabled it to continue production and reorient sales to the German market. The Ethiopian firm was also well served by an emerging long-distance linkage with a German marketing organization, while the Ugandan collaboration with a Dutch technical institute in conducting soil tests could become an important external linkage asset.

Sustained support in the form of public sector R&D and export marketing assistance that had been a major asset for firms in East Asia will also be needed to sustain a process of continuous innovation in the cut flower system. Already the Ugandan and Kenyan systems share a common set of constraints in the shortage of farm inputs such as fertilizers, pesticides and herbicides. Shortage of aircraft freight space, lack of skills in public institutions to ensure high quality products for the highly differentiated European markets have been identified as immediate and/or potential future problems. Both countries have poor road networks, and poor power supply effectively raising transaction costs. In the Ugandan case, soil tests were carried out in the Netherlands because the National Agricultural Research Organization (NARO) lacked expertise in cut flower production at the time and there was no marketing support that would have assisted in identifying market niche. However significant learning did take place after the initial mistakesm as we saw above. The actor's capability to learn by doing and by interacting show the emergence of new habits and practices that will respond well to new policies and support structures.

Lastly, public support institutions will be required to hedge against the high costs, risks and uncertainties involved in competing in new markets since firms in Africa are too small to undertake the setting up R&D facilities Under the changed competitive conditions, smaller firms will find it increasingly difficult to maintain the level of quality required in the export market without leveraging support through partnerships with actors at home and abroad. African farmers are new to the cut flower business and this place them at a considerable disadvantage since other local actors in this emerging system of innovation have neither the competencies nor the size and degree of internationalization required to compete.

Mining Systems

Transforming a traditional sector into a dynamic system require efforts on all fronts and by all agents in the national system. Peru's mining industry earned $1.37 billion in 1998 using a combination of FDI and substantial domestic technology initiatives. Close to 60% of these earnings come from the technical goods and services sourced locally. Peruvian firms design and manufacture a surprisingly wide array of engineering goods which include milling and treatment equipment for small and medium firms although the country has no capabilities in heavy capital goods such as bulldozers and dump trucks, a market segment dominated by a small number of global players. FIMA, a 29 year-old Peruvian company for example, designs and manufactures a range of mining equipment such as materials handling systems, crushing and grinding equipment, concentrators and cyanidation plants. FIMA controls 80% of the market for small and medium scale mine handling and treatment systems and has stretched these capabilities to supply other resource-based industries. For instance it supplies conveyors, screens and pumps as part of turnkey systems to fishmeal processors. It installed a biological leaching system for gold production under a technology license from a South African producer, Gencor. FIMA has subsequently developed its own system for gravimetric recovery operations as a result of its learning from this project and in part due to the revival of gold mining in the country.

Peruvian firms have acquired key capabilities in the supply of technical services for geological and mining engineering as well as in environmental engineering. The knowledge bases include substantial theoretical capabilities within local universities in geology, mine engineering, environmental and metallurgical engineering. In addition, local firms have formed strategic alliances with foreign design and engineering firms in order to meet the competitive challenges of high quality, and the trend towards large-scale production.[17] The introduction of a relatively new bacterial leaching technique for recovering silver content from mining waste has led to a revamping of the Tamboraque poly-metallic mine located 90 kms East of the capital, Lima. The installation of the state-of –the-art process, was accompanied by a new management organization, and involved collaboration with Instituto Tecnologica Superio (TECSUP), a leading private technical training and research insitute that constructed the pilot plant. FIMA, did the design and scale-up of the plant while two foreign agencies one from Canada and the other from the USA funded the project.

Figure 3 shows a simple system of linkages between non-fuel primary commodity (NFPC) firms and other knowledge systems in the economy. Three activities: production/extraction on farms and mines, followed by firm-level processing and finally by transportation and sales are shown. The knowledge bases are interlocked in an ideal type national system and the model shows that the farm/mines, the firm and an array of suppliers, customers, consultants and trade groups relate and learn from one another. Research institutions interact as closely with farms and mines, as much as they do with firms. Learning is both formal and informal and can be enhanced through trading with overseas partners, and information agents. As illustrated in Figure 1, the above processes are embedded in a global context.

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[17] For example, Grana y Montera, a Peruvian civil and structural engineering firm is in alliance with Kilborn of Canada, a firm of international mining consultants. Bechtel, an influential US firm is in partnership with Peru's COSAPI and Brazil's Odebrecht in the development of the Antamina deposit.

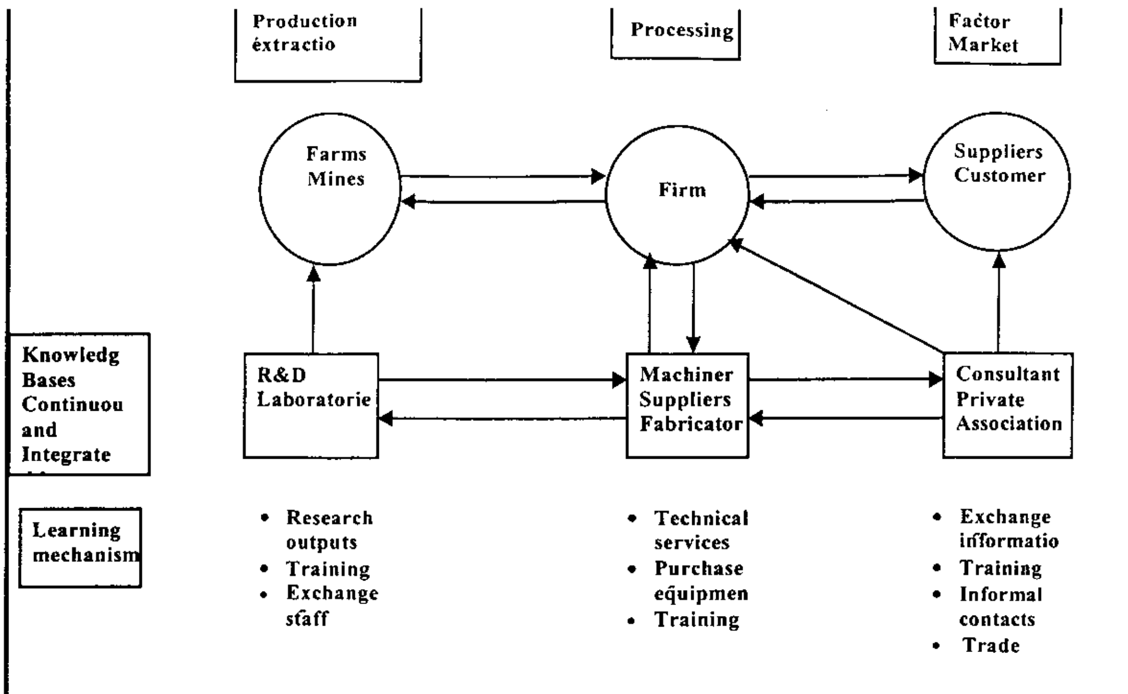


Figure3: Knowledge Bases and Learning in the national systems

Without a firm grasp on the changing nature of competition in globalized agricultural and mining systems, it is no longer possible to assess the dynamics of local innovation systems or develop appropriate policies to stimulate and support them. From a dynamic perspective[18], the re-conceptualization of natural resources sectors as broad, changing systems based on clusters of technologies and solutions[19] meets this new requirement by creating a wider angled lens through which to view the possible entry of new actors, the development of new products and the recombinatory potential of generic technologies. The emerging Peruvian mining system illustrates the ways in which local linkages are formed and where long-distance partnership can contribute to domestic technological capability building.

Food and Beverages

Sustained capability building involves all actors within the national system linking the firm, suppliers, customers, RDIs, independent consultants, and universities. Policy changes can stimulate these changes. One of the most remarkable innovation successes in Nigeria for example, started with a ban on barley malt, in 1988 in an attempt to endogenize the raw materials base of a traditional sector through the use of local cereals for beer brewing. Traditionally African beers are brewed from sorghum and millet but lack the clear and carbonated properties of European beers. The establishment of large-scale brewing plants and the relatively long shelf life of these beers, led to the death of

18 In the preparation of a recent UNCTAD investment policy review, the mining sector in Peru was reconceptualized as a 'mining system'. This broadened the exploitable knowledge-base to include biotechnology from the expertise acquired through bacterial leaching of copper and it became possible to think of commercializing the wealth of information and ideas related to environmentally sound technologies that had been developed as a result of environmental clean-up activities in this industry.

19 A related approach can be found in Carlsson (1997) where industrial sectors are conceptualized as 'technology systems'.

the local brewing processes and the rapid growth of the industry in Nigeria. By 1984 Nigeria had 33 breweries producing 11.4 hectolitres of beer from 161,053 tonnes of imported barley malt, (FOS, 1985). The recession and loss in export earnings from petroleum prompted the Government to target certain sectors as candidates for "import deletion". The brewing sector was one of them and in a short time, the ban on barley malt led to closures, and drastic production cuts. By 1988, only a dozen firms remained in business.

Two categories of firms survived: the two strong industry leaders with a long history of beer production, and strong affiliates of well known European MNCs that gave continuous technical support to domestic innovation efforts. The second group comprises large to medium producers with majority Nigerian ownership but with far less asset base and no formal technical partnership with MNCs. The two industry leaders and to a lesser degree, the other surviving firms, prospered by rapidly converting process lines to accommodate the local maize grits and the sorghum variety. They did this by tapping into both local (recruiting engineers and scientists from universities who had worked on laboratory conversion process); and foreign knowledge bases (from technical partners). The Institute of Agricultural Research (IAR), Ahmadu Bello University, Zaria, Nigeria had through long years of experimentation identified the right sorghum variety. Work on substitution of sorghum malt for conventional brewing process had gone on at the Federal Institute of Industrial Research, Oshodi (FIIRO), in university laboratories at the University of Ife, and at another federal institute, Project Development Agency (PRODA), Enugu in Eastern Nigeria. FIIRO had in fact built sorghum malting pilot plant but there was no one to do the scale-up (as did FIMA of Peru for the biological bleaching process). The ban, and the threat to firms' profit, induced subsequent scale-up and commercial production, (Oyelaran-Oyeyinka, 2001).
The lessons of the brewing conversion process are many but the most striking, was the use of knowledge bases within the national system in responding to what was clearly a crisis, by the firms.

Table 2 Manpower Growth in Brewing Firm

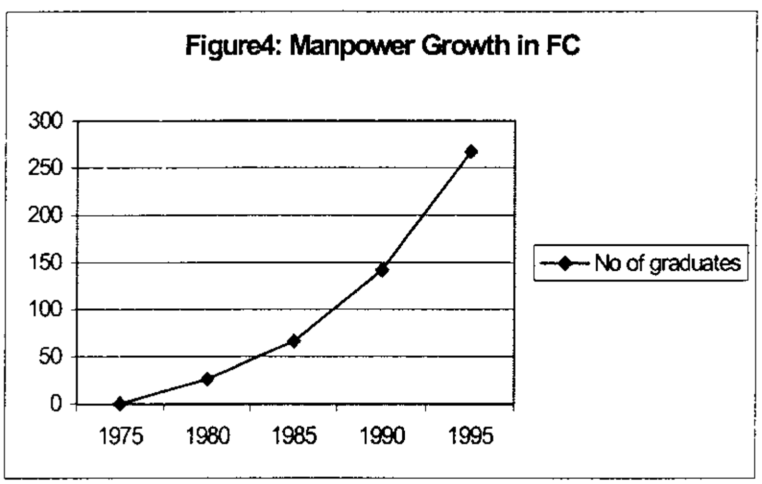
Category	1985	1989	1990	1999	2000
Management	343	231	248	350	296
Engineers &Technicians	2748	2625	2586	2519	1979
Total	3998	3903	3942	3673	2884
Skill Intensity	0.687	0.670	0.66	0.685	0.686

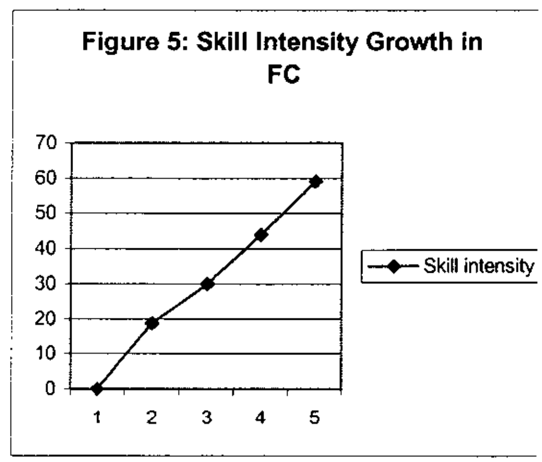
Source: Annual Report and Accounts 1985-2000

The ban had the same effect on other firms in the foods, and beverages sector. Some large firms, employing thousands of employees in the beverages sector responded in like manner by re-tooling, re-equipping their R&D departments and staffing them with top class engineers and scientists. Table 1 and Figures 4 and 5 show the skill response of two of large firms, one producing beer and the other, and confectionery. Skill intensity, the ratio of skilled engineers, scientists and technicians to total staff is very high for a sector traditionally considered "low-tech". This particular beer producing firm is in technical partnership with a Dutch brewing firm and senior engineers in the Nigerian firm regularly undergo training in the collaboration with the technical partner.

It has five plants located in major commercial centres in Nigeria and has, in response to the pressures of competition, branched into both non-alcoholic malt and "stout" market.

The confectionery firm (herein labeled FC), employed about 2000 persons in 1995. The firm was established in 1964 and revenue grew rapidly from1969 to 1981 to the extent that FC had to import finished goods from India and the UK to meet market demand. It was at this time that it began expansion plans and made serious efforts to utilize local raw materials. The firm made use of four main ingredients shown in Table 2. The motive was clearly to increase company earnings by import substitution, as malt extract is 18% water, adding considerably to freight cost. The first malt extract plant was installed in 1976 and scraped in 1991 (the period when other firms were also converting) and replaced the old plant with a purpose built plant to process sorghum and maize. According to firm accounts, "this investment transformed the cost structure of our star product, and strengthened the company's balance sheet; it had been central to the survival and growth of the company"[20]. The phenomenal growth of FC and its consistent performance over the years can be attributed to its emphasis of innovation, and the use of what it called "knowledge workers". The company went from having no graduate engineers and scientists in 1975 to 267 comprising by 1995, largely physical scientists (Food science and technology, biochemists, and microbiologists) electrical, mechanical, chemical, and industrial and agricultural engineers. FC had been strong in in-house research and has collaborated with IAR, Zaria and FIIRO, Lagos but its had taken out a patent on its cereal conversion plant.





[20] Paper presented by the Operations Director of FC, July 1996 at a seminar organized by the Regional Centre for Technology Management, Lagos, Nigeria.

Table 2 Changed Profile of Inputs in FC (Confectionery Firm)

ingredients	made from	source
1) malt extract	malted barley (sorghum)	Europe (Nigeria)
2) cocoa powder	cocoa beans (cocoa beans)	Nigeria
3) glucose	corn processing (corn/sorghum)	Europe (Nigeria)
4) skimmed milk powder	dairy industry	Europe
5) sugar	cane sugar	Europe

Source: company records. Items in bracket shows sources after conversion

The nature of relationships between actors is also brought into relief within a system of innovation approach. Thus, in the context of sector-based clusters built around the value chain, relationships between actors consist mainly in the unidirectional transfer of information from a client to its suppliers. Two-way partnerships are a rarity. It may indeed be the case that traditional habits and practices do not predispose actors to a more innovation-oriented form of interaction in which knowledge is shared and learning maximized, though this can change as the relationship between first tier preferred suppliers and automobile assemblers has shown. An analysis that sheds lights not only on the configuration of actors in the system but on their traditional habits and practices and the nature and intensity of their interactions provides critical new information for policy-making.

To transform both spatial and sector-based activities into dynamic innovation systems, the habits and practices of actors central to the innovation process and the nature of their interaction must change. Drivers of this process may come from business associations, enterprises, NGOs or the public sector as the cases of ASOCOFLORES, the Columbian Association of Flower Exporters and CENICAFE illustrate, (UNCTAD, 1999). But success is often shaped by the knowledge base and competencies that actors bring to the process of interaction. The higher the competencies of these actors, the wider are the opportunities for learning through interacting. This suggests that innovation policy cannot be developed in isolation from other policies that support an innovation process such as education, training, and R&D policies.

5.0 Conclusions: From Static to Dynamic Systems: Lesson Learned

Mapping the knowledge base within a context marked by dynamic industrial change, assessing the competence of actors within these systems and benchmarking them against global practices are thus essential inputs into the design of innovation policies. From this perspective, the system of innovation approach has the potential to become a powerful tool for national and local policy-making. It provides a new way to organize knowledge as an input into policy making, a means to analyze the support structures and policies needed for innovation and a framework for situating the local in the context of dynamic processes of change at the global level. This is particularly important in designing policies to support learning and innovation in natural resource industries and in the SME sector.

In contrast to the quasi-autonomous process of learning by doing, learning to learn is a conscious process in the absence of which firms neither improve productivity nor develop the capacity to innovate in products or processes as competitive conditions change. The linkages firms establish with clients and suppliers at home and abroad can be critical in this respect. The accelerated pace of technological change, moreover, requires a far larger volume and set of resources than small, medium, and even large firms traditionally have in-house or can easily access. These resources are both knowledge-based and financial. SMEs in particular, lack buffers that reduce the risks of change. Having limited scanning capabilities because they are small and limited financial resources because banks and capital markets are not sufficient providers to this sector. Technology partnerships are thus increasingly vital for SMEs seeking to keep up and get ahead. To a certain extent, the ability to sustain large-scale in-house R&D efforts that conferred clear advantages upon larger firms in the past, can also be matched by the flexibility and size of the network to which smaller firms belong. These networks and partnerships provide critical support to innovative activity at the technological frontier (Mytelka & Delapierre:1999). Indeed, participation in such networks and the skill with which a portfolio of partnerships is managed have become essential to a firm's ability to catch up and keep up as competitive conditions change. By turning themselves into learning institutions, firms that do 'learn to learn' during the catch-up phase moreover, are better able to sustain their competitiveness through innovation over the longer term.

Learning, however, is not solely the province of the firm. System-wide learning as we have shown, supports firm-level learning and is a prerequisite for keeping up. Knowledge gained in carrying out a set of tasks can be broadened and re-used in new activities. The knowledge of enzymes acquired in mineral bleaching can be developed for a variety of purposes such as environmental clean-up. Enzymes are also important agents in foods and beverages for example in the conversion of cereals into malt in the brewing industry. A systems view of such knowledge gained across "subsystems" opens important windows of opportunity to deepen local linkages.

Comparative advantage in natural resources by itself is a static condition that can no longer form the basis for competitiveness. Regarded as a platform, from which dynamic conditions can emerge, natural resources can become a platform for catch-up. New technologies have revolutionized traditional sectors from mining, agriculture, and fishing to services. The old notion that divides sectors into "hi-tech" and "low-tech" based strictly on R&D-intensity is misleading viewed against the progressive intensification of knowledge across all sectors. In other words, as the examples cited here show, traditional sectors such as mining, food and beverages, and horticulture are being transformed into knowledge-intensive systems.

Export capabilities, as other knowledge capabilities, involve considerable explicit efforts in mastering the techniques of long distance handling and transport of fresh products. Building a system involves diversification, a process that demands linkages in several directions. For instance, upstream linkage fosters interaction and learning from the capital goods sub-system, and input suppliers. Downstream linkage promotes links with auxiliary producers, and greater value added in the final products and services market. Classical examples in the mining sector include aluminum and steel but equally, tremendous opportunities exist within the foods, beverages and agricultural raw materials such as cotton, and coffee. Traditional sectors therefore provide a useful platform for Africa's catch-up but policy makers need to reconceptualize these sectors as innovation systems for their dynamic potential to become more evident.

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