Towards Technology Models for MSEs in Kenya: Common Principles and Best Practices

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Abstract

Global business pressures generated by globalization and liberalization have shifted emphasis from traditional factors of competitiveness (such as price reductions) towards new forms of competitiveness (such as innovation and knowledge creation). Despite this, Micro and Small Enterprises (MSEs) in Kenya operate within restricted levels of technology and most of them use inappropriate technology. They lack capacity for modern technological adoption and absorption. This paper reviews the theories, existing institutional framework and practices of technology acquisition for Kenyan MSEs and a few selected countries with the aim of developing a model for MSEs technology development. The theoretical review reveals the importance of the spatial dimension, supportive infrastructure, market forces and entrepreneurial orientation and synergy in MSEs technology development approaches. The paper finds that MSEs have operated in an environment that lacks a coherent and comprehensive technology and innovation policy framework. Best practices from other countries highlight the need for increased public support; deepening of market forces; promotion of inter-firm linkages; developing mentoring programmes for "techno-preneurs" and promoting intellectual property rights. Further, lessons indicate that MSE associations, metrology and standards, research and development are critical in technology development. On the basis of these arguments, the paper proposes a theoretical model for MSEs technology development. The model is built on a foundation of five pillars that include: the Government ; science, technology and engineering education institutions; innovation and technology markets; financial institutions; and business enterprises. The model should be useful to MSE associations as they lobby for implementation of MSE policies on technology.

Abbreviations and Acronyms

ACTS	African Centre for Technology Studies
ARC	Agricultural Research Council
AT	Appropriate Technology
CBS	Central Bureau of Statistics (Kenya)
ECA	Economic Commission for Africa
ERSWEC	Economic Recovery Strategy for Wealth and Employment Creation
FDI	Foreign Direct Investment
HACCP	Hazard Analysis and Critical Control Points
ICDC	Industrial and Commercial Development Cooperation
ICEG	International Centre for Economic Growth
ICT	Information Communication Technology
IPR	Intellectual Property Right
ITDG	African Technology Policy Studies Network
KARI	Kenya Agricultural Research Institute
KEBS	Kenya Bureau of Standards
KEMRI	Kenya Medical Research Institute
KEPHIS	Kenya Plant Health Inspectorate Services
KETRI	Kenya Trypanosomiasis Research Institute
KIE	Kenya Industrial Estates
KIPI	Kenya Industrial Property Institute
KIPO	Kenya Industrial Property Office
KIPPRA	Kenya Institute for Public Policy Research and Analysis
KIRDI	Kenya Industrial Research Development Institute
MACs	Manufacturing Advisory Centres
MSE	Micro and Small Enterprise
MSED	Micro and Small Enterprise Development
NCSE	National Council on Small Enterprise
NCST	National Council for Science and Technology
R&D	Research and Development
SME	Small and Micro Enterprise
TVET	Technical Vocational Entrepreneurship Training

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1. Background

1.1 Study Context

This study relates to one of the components of a three-year USAID - supported project on "Enhanced Policy Formulation and Implementation for Micro and Small Enterprises - MSEs" as proposed and implemented by KIPPRA (2003). The aim of the project is to increase the level of adoption of policy recommendations and therefore narrow the gap between policy formulation and implementation. The three components of the project are: (1) Capacity Building and Training; (2) Coordination, Monitoring and Evaluation; and (3) Empowerment of sectoral MSE organizations.

In the third component, KIPPRA proposed to develop a strategy to empower sectoral MSE organizations by designing a programme that would enhance their access to workspaces, marketing and technology. This would be achieved by: (a) conducting a capacity needs assessment for sectoral MSE organizations; (b) undertaking a situation analysis on workspaces, marketing and technology; and (c) developing appropriate models to improve institutional capacities.

According to the project design, the implementation of activity (c) would draw from the outputs under (a) and (b) above, and will involve two stages. In the first stage, theoretical models on workspaces, marketing and technology will be built drawing from secondary sources. This is rationalized by the reasoning that undertaking the situation analyses and designing models on workspaces, marketing and technology needs a thorough understanding of theory, policy and best practices. Such an understanding would guide the construction of survey tools and provide the theoretical basis for the models. At the second stage, the theoretical models will be field-tested to yield empirical models that would be modified in line with comments generated from stakeholders and KIPPRA staff. Empirical models will be adopted by MSE associations to lobby for improved implementation of policies to access workspaces, technology and marketing services. Given the above reasoning, three background studies, relying heavily on documentary analysis, would be undertaken. The three background studies are;

- Towards technology models for MSEs in Kenya: Common principles and best practices;
- Misallocation of workspaces for MSEs in Kenya: Some lessons and models; and
- Developing a marketing model for MSES in Kenya.

This paper is one of the three background studies. It has been designed to package the theory, policy and best practices in technology and thereafter develop a model that could be adopted by MSE associations for use by MSEs.

1.2 Motivation

Whereas Kenya expects MSEs to play a central role in employment, industrial transformation and poverty reduction, the competitiveness and growth prospects of MSEs fall below the levels required to meet challenges posed by these expectations[1]. Further challenges posed by globalization and liberalization suggest that MSEs must be internally

[1] The Economic Recovery Strategy for Wealth and Employment Creation acknowledges the role of the MSE sector in generating growth, creating jobs and reducing poverty (Government of Kenya, 2003). The strategy paper expects over 88% of the 500,000 jobs to be created in this sector. The sector contributes about 18% of GDP and plays a critical role in easing the foreign exchange constraint, in penetrating new markets and in stimulating growth and development particularly in the rural areas. In addition, the sector acts as the seedbed for entrepreneurial pursuits and complements the process of adjustment in large enterprises by emerging as competent suppliers of products and services previously not available in the market.

and internationally competitive to survive and grow (UNIDO, 2002)[2]. The ability to create, distribute and exploit knowledge has become a major source of competitive advantage. In a market-oriented environment, one way of achieving and maintaining competitiveness is by creating knowledge faster than competitors (Albu, 1997; Maskell and Malmberg, 1999). In turn, this depends on cost advantages, innovation and the continuous improvement of products and services —all coming through the capability to generate and manage technical change.

As implied by new growth theories[3], organizations of all shapes and sizes need to adapt to survive. Central to this is the potential of applying technology as way for adapting and surviving (UNIDO, 2004). By extension, it is not possible for MSEs to grow and become competitive without technological change and accumulation of knowledge (Buainain, 2002). Just like training, finance and business premises, technology is often seen as an important factor influencing the productivity and competitiveness of MSEs, but not always accessible to them. Without access to technology, MSEs lack the capability to produce efficiently, meet deadlines, upgrade product quality and evolve new product designs. It is only MSEs with the capacity to initiate improvements in products, processes and production organizations that take advantage of the emerging opportunities[4]. However, as argued by UNIDO (2004):

[2] Some of these pressures are coming from increasing competition, the changing basis for competition, shifting patterns of legislation and regulation, tumbling trade barriers and fragmentation of markets (UNIDO, 2004)

[3] These theories are also termed endogenous growth models. They lay emphasis on technological change and accumulation of knowledge (education, on-job-training, innovation and inventions) as drivers of growth of enterprises and economies (Ikiara *et al.*, forthcoming).

[4] This applies to both *sophisticated technology* needed for the competitiveness of small enterprises in the modern manufacturing and services sectors, and *appropriate technology* needed for small enterprises operating in the labor-intensive, low-skill spheres.

"It is a misconception that, acquisition of new technology is a panacea for all the problems of SMEs and that it can be done by all and sundry with only the power of finance. Acquiring new technology and applying it to get the advantage of competition and sustained productivity would require basic capacity to assimilate the technology, to manage and control results with it; otherwise, dealing with new technology, even more sophisticated technology, could be like catching the tiger by the tail" (UNIDO, 2004).

In Kenya, much of the existing technology available to MSEs is either insufficiently productive to create secure livelihoods with the available resources, or cannot produce goods of a quality or type that enables them to break into new, expanding or more demanding markets. This is because choosing a technology requires specific skills and knowledge that MSEs just do not have (Buainain, 2002). Making the right technology choice requires capacity for continuously adapting the technology to their particular needs and also continuously improving their use of technology assets by innovating. Therefore, MSEs need to upgrade their own internal technology effort.

The Sessional Papers No. 2 of 1992 and 2005 (Government of Kenya, 1992, 2005) clearly summarize the problem of technology in Kenya. These papers state that MSEs have restricted levels of technology, inappropriate technology and inadequate institutional capacity to support adaptation and absorption of modern technological skills. Such enterprises suffer from lack of information on existing technologies and are exposed to a weak environment that hampers coordination and transfer of technology. In some instances, small enterprises simply have no way of gauging the appropriateness of technologies. In addition, there is a wide gap between the suppliers of technology and the end users of technology products (Government of Kenya, 2003). Effective transfer of technology is not taking place in the country because decisions relating to most aspects rest with multinational corporations (MNCs) (Government of Kenya, 1982).

1.3 Study Objectives and Approach

The overall objective of this study is to develop a theoretical technology model for MSEs in Kenya. In order to achieve this objective, the study applies a descriptive analysis of theory, policies and regulations as well as empirical and case study evidence. The theoretical review is limited to arguments that have been advanced to explain the links between technology and firm growth. The analysis of policies involves a critical review of their successes, failures or implementation gaps.

Notably, case study evidence is limited to seven countries—Botswana, South Africa, Mauritius, Singapore, Brazil, United Kingdom and United States. The inclusion of Botswana, South Africa and Mauritius is more or less obvious—they are best performers in Africa not only in terms of innovation and technology effort but also in terms of economic performance. Singapore is drawn from the group of newly industrializing countries while Brazil is selected from the South American cluster of countries. The inclusion of UK and US in the sample may not be obvious especially for a study on MSEs. The two countries are included since among the developed countries, they are some of the best performers in the area of technology. We acknowledge the fact that the selection of this case study sample may suffer from selection bias. While unintentional, it was not possible to include some of the countries for lack of information. Notwithstanding this limitation, it is hoped that extracting best practices from the seven countries, and combining this with balanced theoretical and empirical reviews, should help us to design a realistic theoretical technology model for MSEs in Kenya.

1.4 Study Scope

This study adopts the definition of MSEs as applied in the National Baseline Survey (CBS, ICEG and K-REP, 1999). Using this definition, MSEs are defined on the basis of three criteria. The first is the number of employees. Micro enterprises are those firms employing up to ten workers (including the working owner). Small enterprises are those firms employing more than ten and up to fifty workers. Therefore, MSEs will include informal sector activities, which employ one or more persons, and enterprises in formal sector employing up to 50 persons. An MSE will encompass activities undertaken at home, on the street or through a mobile unit and will include enterprises run either as the main activity or as a secondary activity. MSE employment may be permanent, temporary, casual or seasonal.

According to the second criterion, we define an MSE to include those firms that are essentially non-primary businesses. This includes non-farm business activities but excludes agricultural production, animal husbandry, fishing, hunting, gathering and forestry.

On the basis of the third criterion, MSEs will include farm-based business activities that involve some form of processing before marketing. Therefore, if household members process their farm products and sell them from the farm or if they are involved in selling farm-based commodities, these are considered MSEs. A farmer who sells roasted maize (a form of processing) at the market place or by the roadside is running an MSE.

The purpose of technology transfer and development is to improve productivity of enterprises, and enhance the quality of goods produced by enterprises to help them withstand local and international competition (ILO/UNDP, 2000). Although this applies to all sectors of the economy, this study is biased towards MSEs in the manufacturing sector.

1.5 Structure of the Report

This report is structured as follows. Section one is the introduction to the study and provides some background information. Section 2 examines some common terms used in the area of technology and reviews technology theories. In section 3, we review existing technology policies and studies. In addition, we discuss the role of technology support institutions in Kenya. Section 4 reviews the seven case studies. The discussion ends with a proposed technology model in section 5 and some concluding remarks in section 6.

2. Concepts and Theory

2.1 Concepts

2.1.1 Appropriate technology

The history of technology development and MSEs in developing countries started with the *appropriate technology* (AT) movement in the 1970's, which subsequently led to the idea of *technology capability* in the 1980's (van Dijk, 2001). The AT movement saw technology as a resource that can only be useful if adapted by firms to improve their efficiency and factor productivity. *Appropriate technology* is defined as technology that is suited to the needs of small enterprises operating in the labour-intensive, low-skill spheres and using local materials and resources (Buainain, 2002, Ngahu, 1995).

The AT movement was initiated by international organizations and Non-Governmental Organizations, and subsequently replicated by local organizations (ILO/UNDP, 2000). MSEs were the beneficiaries of the incremental technological improvements, rather than active participants in the process. Local and foreign experts developed the technologies, and they identified small tools and equipment manufacturers needed for the production of the improved tools or equipment, and provided training in the use of improved technology. Although this approach to technology development achievement achieved some success, it has been criticized for having minimal impact on the technological capacity of developing countries. It has been challenged for focusing its attention to MSEs and yet failing to narrow the gap between MSEs and larger enterprises.

The technological capability paradigm has faulted the appropriate technology movement on these grounds and proposed policies for increasing the technological capability that encompass all enterprises, whatever their size. This is based on the reasoning that medium and large enterprises may not be able to achieve a sufficient level of competitiveness unless they establish strong linkages with MSEs that are also technologically advanced. The experience of developed countries reveals small technology gaps between small and large firms, allowing the former to take over some of the technology development activities of the larger firms.

As noted above, the experience of the appropriate technology movement has been less than satisfactory. On this basis, Aduda and Kaane (1999) argue that the AT movement is responsible for the failure of Kenya to develop a technology vision and since AT has been understood, not in terms of the capacity to produce market or demand-led products, but in terms of older generation or manual technologies. The AT movement focused on the incremental technological development of the country, even though the technological development of MSEs should have been part and parcel of an overall national technology development plan (ILO/UNDP, 2000).

2.1.2 Technology and technological capability

Since most innovation occurs elsewhere (mainly through research and development – R&D) and later flows away from the locus of innovation, firms that receive technology developed elsewhere require *technological capability* for them to make effective use of the transferred technology. Engineering, technical skills and effort are required by small firms for them to adapt the technology to different climate, raw materials, different product characteristics and different skill availability. *Technological capability* is defined as the information and skills — technical, managerial and institutional—that allow productive enterprises to utilize equipment and technology efficiently (Biggs, Shar and Srivastava, 1995). It is the ability to make independent technological choices, to adapt and improve upon chosen techniques and products and eventually to generate new technology, endogenously (van Dijk, 2001).

According to Albu (1997) technological capability can be broken down into *production capability*, *investment capability* and *innovative and adaptive capability*. Production capabilities[5] are those skills, knowledge and resources that are needed to use existing plant and process efficiently to make established products. Investment capabilities involve those skills, knowledge and resources that enable firms to expand workshop facilities, procure and install standard equipment; and to search for, evaluate and select technology and its sources for new production projects. Innovative capability consists of the skills, knowledge and resources that enable firms to assimilate, change and create technology.

Technology development[6] refers to the design of new machinery, equipment, production processes, materials and the methods of organizing production. *Technology adaptation* is the modification of an existing technology to meet the needs of specific types of producers or consumers, become compatible with locally available materials or local tastes and preferences, or take advantage of a relative abundance of labour relative to capital. Technical change implies four stages starting with the introduction of new technology (van Dijk, 2001). Imitation is the second, adaptation the third and innovation the fourth.

[5] Production capabilities can be distinguished into product technological capability (improvements in product design or the introductions of new product designs) and process technological capability (plant design and the layout of the production line, quality control, maintenance and repair, and industrial engineering (Biggs, Shar and Srivastava, 1995).

[6] This is closely related to *innovation*, which is the introduction of new ideas, goods, services and practices that are intended to be useful. It is also related to invention. According to Iyigun (2000) *invention* refers to the discovery of new technologies whereas *innovation* refers to the improvement of the existing technologies.

Technology is imprecise in terms of definition[7] and is perhaps one of the most misunderstood concepts. Earlier definitions of appropriate technology have been considered narrow as they considered the technique and knowledge aspects, i.e. "technology choice", and assumed away the relative resources, knowledge and skills of the people involved (Jeans, 1999). According to Aduda and Kaane (1999), any technology (whether mechanical technology, biotechnology or information technology) cannot be merely reduced to hardware or machines alone but should be seen as involving certain kinds of tacit knowledge embodied not only in hardware, but also in persons, organizations and cultural practices.

Broadly, *technology* is "the science and art of getting things done through the application of skills and knowledge" (Smillie, 1991 cited by Albu, 1997). It is a body of knowledge of techniques, methods, processes and designs (Aduda and Kaane, 1999). Specifically, technology has been defined to encompass the know-how, techniques and tools. Jeans (1999) defines technology to encompass four elements:

- *Technique:* the specific configuration of machines and equipment required to produce a good or service (the hardware).
- *Knowledge:* comprising knowledge of science and technology, skills, experience, know-how and attitudes (software).
- *Organization:* the institutional arrangements by which the technique and knowledge are combined, and the means by which they are managed (partly hardware, partly software and partly knowledge).

[7] For instance, Arora et al (2000) argue that this imprecision in the definition is due to the fact that technology comes in many different forms – it can take the form of "intellectual property" (patents) or intangibles (e.g. a software program, or a design), or it can be embodied in a product (e.g. a prototype, or a device like a chip designed to perform certain operations), or it can take the form of technical services.

- *Product:* the good or service resulting from the technique, knowledge and organization.

In this paper, and in the context of MSEs, technology will be applied to refer to the way of doing things. This ranges from the way a product is made and designed, how raw materials are sourced and used, how the production line and workshop is designed and structured, how products are distributed and stocked. It also includes how the MSE is managed and how the various phases of production or departments are interlinked both within and outside the MSE. It also encompasses the way of financing production, the way power is acquired and so on. Therefore, although the plant, machines, equipment and products may not constitute technology *per se*, they will embody the inherent technology. A business person who uses a charcoal saving *jiko* to roast maize for sale at the market place can therefore be considered to be using a better process technology.

2.1.3 Technology parks

The International Association of Science Parks (IASP)[8] defines a science park[9] as "an organization managed by specialized professionals, whose main aim is to increase the wealth of its community by promoting the culture of innovation and the competitiveness of its associated businesses and knowledge-based institutions. To enable these goals to be met, a science park stimulates and manages the flow of knowledge and technology amongst universities, R&D institutions, companies and markets; it facilitates the creation and growth of innovation-based companies through incubation and spin-off processes; and provides

[8] This is the official definition as adopted from http://www.iasp.ws/

[9] The definition encompasses other terms and expressions such as "Technology Park", "Technopolis", "Technopole", "Technology Precinct", "Research Park", etc.

other value added services together with high quality space and facilities".

Therefore, science parks are established to support the establishment and growth of technology-based enterprises (British Council, 2002). Similarly, they enable the established enterprises to access technical expertise and management support for its tenant companies.

2.1.4 Markets for Technology

There is increasing emphasis on markets in resource allocation, and on market-led technology identification and development. Despite this, technology markets are still very thin in developing countries (ILO/ UNDP, 2000) and a thorough understanding of how these markets work is still lacking. Markets are thin in developing for the following reasons. First, there is lack of awareness of the potential importance of these markets. Second, there is limited industrial capacity to bring innovations to the production stage; and, finally, there are substantial difficulties in protecting one's innovation. The foregoing notwithstanding, there is evidence that the existence and functioning of markets for technology can profoundly influence the creation and diffusion of new knowledge, and therefore, the growth and competitiveness of firms (Fosfuri , Ashish and Gambardella, 1999). This is because markets for technology affect the role of firms both as technology users (they can now buy technologies) and as technology suppliers (they can now sell technologies) (Arora, Fosturi and Gambardella, 2000).

Since technology is either tangible or intangible, market transactions in technology may not necessarily involve the exchange of "a good for money" but may take many different forms including pure licensing of well-defined intellectual property, collaborative agreements (which may include further development of the technology, or its realization "from scratch"). Arora, Fosturi and Gambardella (2000) define a market for technology to refer to "*transactions for the use, diffusion and creation of technology. This includes transactions involving full technology packages (patents and other intellectual property and know-how) and patent licensing. It also includes transactions involving knowledge that is not patentable or not patented (e.g. software, or the many non-patented designs and innovations)*".

Where technology markets are underdeveloped and inefficient, gains from trade in technology cannot be realized. Trade in technology allows the firm that develops the technology to potentially gain by selling to other firms, including other firms in other industries and countries. Innovations can be actively marketed by for instance organizing "innovation fairs" to facilitate deals between innovators and manufacturers (ILO/UNDP, 2000). These benefits would be greater if the innovating firm is incapable or unwilling to exploit the technology itself. There is also lower innovative effort where technology markets are absent. This is because firms that possess the innovative capacity but lack the commercialization capacity will have no incentive to invest in innovation. This constraint may disproportionately adversely affect small firms (that play a bigger role in the commercialization of technology) than large firms that play a bigger role in industrial innovations (Cordes, Hertxfeld and Vonortas, 1999).

2.1.5 Intellectual Property Rights

According to WTO[10], intellectual property rights are the rights given to persons over the creations of their minds. They usually give the creator an exclusive right over the use of his/her creation for a certain period of time. Although, intellectual property rights are customarily divided into two main areas: copyrights and rights related to copyrights and

[10] See <http://:wto.org/>

industrial property[11], they are simply copyrights, trademarks, trade secrets and patents (UNIDO, 2004).

The World Intellectual Property Organization considers IPRs important to small firms as they are to large businesses[12]. This is because any business would usually have one or more trademarks, confidential business information or creative original designs. Alternatively, some firms may have produced, or assisted in the publication, dissemination or retailing of copyrighted work. It is also possible that that some of MSEs may have invented or improved a product or a service. In all such cases, the MSE may wish to use the intellectual property system to its own benefit. Intellectual property has the potential to assist MSEs in every aspect of business development and competitive strategy: spanning from product development to product design, from service delivery to marketing and from raising financial resources to exporting or expanding the business abroad through licensing or franchising.

2.2 Theory

Our line of inquiry in this section is to understand technological factors that lie behind firm growth and processes involved in technology transfer, acquisition, adaptation and innovation.

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[11] (i) Copyright and rights related to copyright: The rights of authors of literary and artistic works (such as books and other writings, musical compositions, paintings, sculpture, computer programs and films) are protected by copyright, for a minimum period of 50 years after the death of the author; (ii) Industrial property: Industrial property can be divided into: (a) the protection of distinctive signs, in particular trademarks (which distinguish the goods or services of one undertaking from those of other undertakings) and geographical indications (which identify a good as originating in a place where a given characteristic of the good is essentially attributable to its geographical origin); (b) Other types of industrial property include inventions (protected by patents), industrial designs and trade secrets.

[12] Refer to "*Why is intellectual property relevant to your SME*?" accessible at http://www.wipo.int/sme

2.2.1 Industrial clusters

The industrial cluster theory, which stems from the idea that firms coalesce to form an industrial district, focuses on institutions, agglomeration economics and cooperation of firms (Cetindamar, undated). Industrial clusters are any form of industrial organization that is characterized by the spatial concentration of many firms in a similar industrial branch (Albu, 1997). Firms, usually MSEs, in industrial clusters are not just physically agglomerated but will usually specialize in carrying out particular processes or stages in the production and distribution channel. Such specialization allows them to engage in a complex web of inter-firm networks that extend beyond market transactions. The transaction density of the networks improves the larger the agglomeration and external economies accruing to the firms. For MSEs, such agglomeration economies allow them to ease the shortcomings of their small size.

Industrial clusters are defined in various ways (Box 1). More elaborate definitions of industrial clusters are provided by Schmitz (1995) and Rabellotti (1995). Schmitz (1995) associates industrial districts with: geographical and sectoral concentration of firms; Predominance of small and medium-sized firms; Vertical disintegration (at the firm level);

Box 1: Clusters—Some definitions

Porter (1998): A geographically proximate group of interconnected companies and associated institutions in a particular field, linked by commonalities and complementarities.

Swann and Prevezer (1998): A group of firms in related industries at a particular location.

Crouch and Farrel (2001): A tendency of firms in similar types of business to locate together, though without having a particularly important presence in an area.

Van de Berg, Braun and van Winden (2001): Localized networks of specialized organizations, whose production processes are closely linked through the exchange of goods, services and/or knowledge.

Source: British Council (2002)

Cooperative competition; and socio-cultural identity, which facilitates trust and active self-help organization. Rabellotti (1995) has identified four key factors that characterize industrial districts as: cluster of mainly small and medium-sized enterprises spatially concentrated and sectorally-specialized; a set of forward and backward linkages, based both on market and non-market exchanges of goods, information and people; a common cultural and social background linking economic agents and creating either explicit or implicit a behavioral code; and a network of public and private local institutions supporting the economic agents acting within the cluster.

It therefore makes sense to argue that the existence of externalities among enterprises affects their technological performance through synergistic networks. Clustering can build industrial capacity by increasing market access, fostering communication and information sharing, enhancing technology spillovers, increasing efficiency, and contributing to the development of support institutions (McCormick, 1999). However, at a general level, networking that comes through clusters facilitates externalities related to (a) knowledge about the behaviour of other agents, (b) knowledge about the non-behavioral world (such as prices and technologies), and (c) the benefits of collective or joint action (Collier, 1998).

Clusters that have a lot of relevance to technology are what have come to be termed as "competitive clusters or Porter's clusters"[13]—named after Michael Porter. These are defined as geographical locations where access to resources and competencies give the cluster a key position in a given economic branch of activity, with a decisive sustainable competitive advantage over other places or even world supremacy in that field. Such clusters affect competition in three ways: (i) by increasing

[13] See http://www.absoluteastronomy.com/encyclopedia

the productivity of the companies in the cluster; (ii) by driving innovation in the field; and (iii) by stimulating new businesses in the field. The location of industries with similar technologies in close proximity to each other has the effect of speeding up their technological development (Cetindamar, undated). Some of the channels through which this occurs include:

1) *Technology spillovers* —either horizontal or vertical benefits that arise, outside market transactions, through demonstration-imitation effects[14], competition, labour turnover, research and development, or via supplier-consumer chains.

2) *Infrastructural economies* —these are benefits that accrue to clustered firms in the form of strong institutional connections required to establish technological infrastructure.

3) *Static agglomeration economies*—these are unit cost reductions arising from internal and external economies when it is located together with relatively dense clusters of other firms or specialized resources rather than located elsewhere. Some of these efficiencies are due to a local concentration of customers, sufficient demand, a deep and diversified pool of workers, usage of specialized equipment and services, opportunities for bulk processing, joint research, organized markets for finished products, reduced cost of negotiating and monitoring contracts, the existence of specialized brokers and specialized machinery producers.

4) *Dynamic agglomeration economies* arise due to technological learning and development and adoption of new technologies.

[14] In the literature on spillovers, this is termed either "learning-by-watching" or "reverse engineering" (see Ikiara, *et al.*, forthcoming).

2.2.2 Deterministic and voluntaristic perspectives

The deterministic model is based on the functional relationship between growth (as the dependent variable) and its determinants that represent the business environment (including age, size, sector, etc) (Neshamba, undated). Therefore, the deterministic framework assumes that growth is stochastic so that the process is not amenable to entrepreneurial control, and may also be influenced by history, chance and luck (Hallberg, 1999). The voluntaristic model treats firm growth as a voluntary process. It views the owner-manager and his desire for business expansion as providing the explanation to why certain firms grow while others do not (Neshamba, undated). Therefore, the expertise of the owner-manager plays a central role in the success of business—implying that educational background and technical ability, previous employment experience and management practices are some of the factors that increase the owner manager's ability to grow the business.

2.2.3 Creative destruction perspective

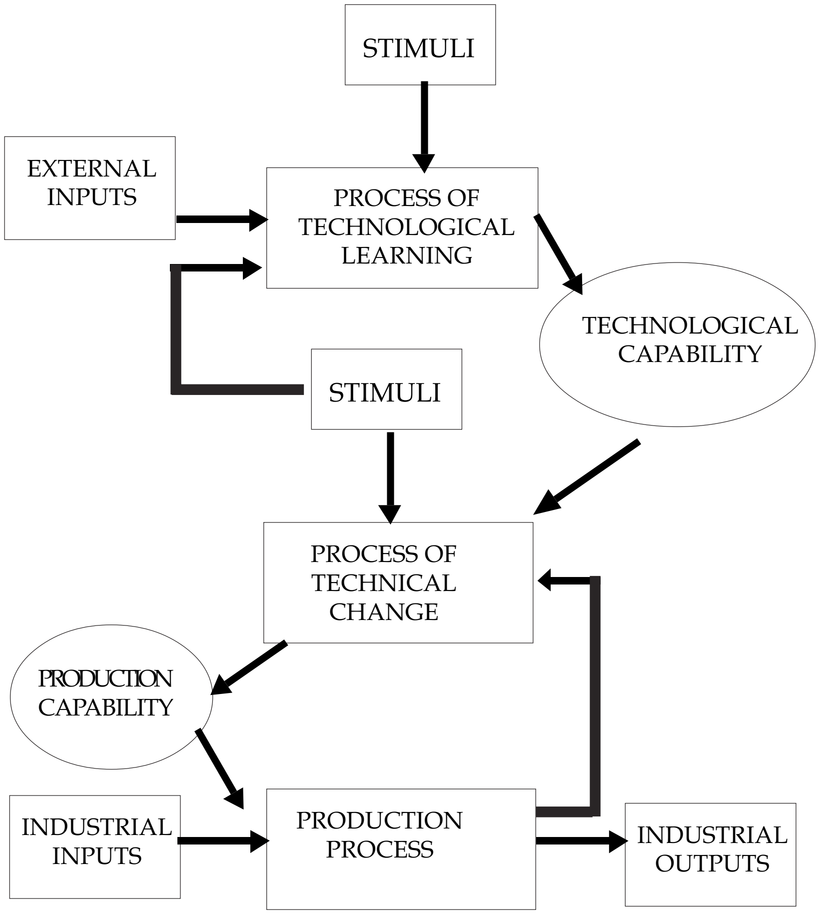
One of the earliest attempts of explaining growth was provided by Schumpeter's creative destruction model. In this model, the preoccupation of innovation and enterprise is to produce new combinations in the form of new products and techniques of production, new markets, and explore new sources of raw material and rearrange markets (Ferrand, 1998; Ahn, 2001). In such an environment, innovations are only successful if they enable the firm to weed out unsuccessful firms through competition. Firms that are not able to remain at the frontier of knowledge creation will lose out and die. Inventors succeed while non-innovators will lose. The key factor determining entry and exit is the innovative capacity (that is to use technology to discover new technology and stay at the top of the knowledge). Firms that *create* and exploit knowledge "*destroy*" their competitors through a gale of "creative destruction".

2.2.4 Technological learning perspective

The literature also identifies the learning process as a factor that explains the birth and death of firms and patterns of their survival and adjustment (Ahn, 2001). Firms need to develop a dynamic capability to renew, augment or adapt their competencies in order to maintain economic performance (Helmsing, 2000). Learning can be passive or active. In both the passive and active learning models, a firm is assumed to enter a market characterized with information asymmetry, and therefore operating under uncertainty. The passive firm will utilize noisy information to successively update, through learning, its knowledge about profitability whereas the active firm scans the competitive environment and actively invests in activities that enhance its competitiveness. Therefore, its future profitability outcomes will respond to the firm's investment and those of other firms.

Applied to technology, the learning process involves a number of components (Huq, 1999). These include the development of human capital, research and development, improved negotiations with the suppliers of technology and the development of science and technology infrastructure (Biggs, Shah and Srivastava, 1995; Huq, 1999; Archibugi and Coco, 2004). Technology learning mechanisms can either be internal to the firms or external (mainly private or collective). Internal learning mechanisms include learning-by-doing, on the job training, organization of technical knowledge and functions and research and development. There are two main external learning mechanisms: private mechanisms, stemming from interactions with the firms buyers and suppliers, and the inter-firm spillovers from horizontal and vertical links, and collective mechanisms. Collective learning mechanisms accrue from efforts by

Figure 1: Technological learning cycle



Source: Albu (1997)

the government, NGOs or donors to create an information-rich environment of institutional or private sources of training opportunities and information sources that address specific business problems and foster the availability of networks of specialized consultants.

According to Albu (1997), technological learning cycles follow distinct phases of technology learning (acquisition of technological capabilities) followed by technological capability (resources needed to generate change). Technological capability is followed by technical change, which results in production capacity (resources needed to produce goods) that results into industrial output. As highlighted in Figure 1, the flow from technological learning to the output is cyclical. The lower cycle represents the technical change process. At the bottom of the figure, the production process converts inputs into outputs. However, at the production stage, the experience gained is used to augment the process of technical change, whose outcomes are improvements in productive capacity.

The upper cycle represents the true technological learning process. As technological capabilities are used to manage the process of technical change, a certain amount of change experience (knowledge feedback) will be derived during the process of technical change and used to augment the process of technological learning. In the figure, firms also use external resources or inputs to build capabilities. These include a variety of skills, knowledge, technical and financial services available from the labour market, from interactions with other firms and from supporting institutions. Stimuli that affect technical change include short-term changes in demand, competitive threats and opportunities and demonstration effects. Stimuli that affect technological learning include government policy encouraging innovation (policy dynamics include tax credits, subsidies, and the pattern of competition, labour practices and so on), culture and norms of social environment and strategic awareness of economic trends.

2.2.5 Life cycle perspective

The technology life cycle perspective has been applied to understand the dynamic and functional role of innovation in product markets and industrial systems (Box 2). The technology life cycle model is based on the premise that the life of a technology is finite. Most new technologies follow a technology lifecycle, which is similar to a product life cycle.

Box 2: Life cycle models

Technology Cycle Model

The precursors stage (bleeding edge): Technology prerequisites and potentials exist but are yet to result in invention or generate value. *Invention stage (also leading edge)*: compared to "the process of birth after an extended period of labor". Combination of curiosity, scientific skills, determination and showmanship to produce a new technology that proves itself in the marketplace but is still new enough to find knowledgeable personnel to implement or support it.

Development: Involves additional creation that can have greater significance than the original invention.

Maturity (also state of the art): Technology has a life of it's own and becomes an established part of the market. Everyone agrees that it is the right solution. *Pretenders:* An upstart threatens the older technology. Gradually, the new technology is found to deficient in some aspects of functionality or quality.

Obsolescence (also dated): A new technology dislodges the established order (older technology).

Decline stage: The original purpose of the technology and functionality of the technology is subsumed by a more spry (state of the art) competitor. Rarely implemented anymore.

Source: http://sll.stanford.edu/projects

Product Cycle Model

New product development stage: It is very expensive. There are business loses since there is no sales revenue.

Market introduction stage: The high cost is followed by high prices. The sales volume is low leading to losses.

Growth stage: Costs reduced due to economies of scale. This increases the sales volume and profitability while prices are adjusted to maximize market share.

Mature stage: Costs are very low, sales volume peaks; prices tend to drop due to the proliferation of competing products, very profitable.

Decline stage: Decline in sales, prices and profits.

Source: http://en.wikipenda.org/wikProduct_life_cycle_management

Industrial Cycle Model

The Industrial Life Cycle model exhibits two major phases: The *first phase* is characterized by radical and rapid technical change. New technologies may destroy the traditional barriers to entry, representing a threat to incumbents using the old set of technologies. The *second phase* reveals some sort of technological consolidation and stabilization around a dominant design. New firms may well be created on the basis of their differentiated knowledge for testing, refining and exploiting such activities. In the case of promising scientific results, such entrants might eventually grow and gain access to preferable positions on new market segments.

Source: Nesta and Mangematin (2004)

New technologies pass through distinct stages of birth, growth, maturity and decline.

At the market introduction stage (birth), the new product, resulting from innovation, is accompanied by an exponential entry of new firms seeking to exploit the market niche (as scale economies become less important) and is followed by growth in demand—as customers demand better technology and more features, regardless of the cost or inconvenience. The growth trajectory from birth to maturity is characterized by turbulence, as declines in demand are succeeded by the leveling off in demand as the market becomes saturated.

Therefore, market entry is easy when the new technology is introduced. All that matters at this stage is faster, cheaper, more powerful technology. However, as firms move towards maturity, they experience relatively stable growth and it is much easier to survive since the available economies of scale have been exhausted and competition has fallen. At this point, marketing concerns dominate technology concerns. However, at the mature stage, where technology is a commodity, user experience and marketing dominate. The implication of the life cycle model is that younger firms have a higher probability of failure than older ones. However, on average, younger firms may have higher growth rates than older firms (Hallberg, 1999).

This model is clearly applicable to Kenya. From a policy perspective, the life cycle theory points to the need for systematic planning for the replacement of technology as it evolves through birth, nurturing, consumption and obsolescence (Aduda and Kaane, 1999). Similarly, it can be used to explain why some local firms[15] have transited from small local firms into medium and large growth-oriented concerns. However,

[15] Excellent examples include East African Spectre, Mareba enterprises, Crescent industries, Ramboo furniture, specialized towels manufacturers, Gotab Sanik enterprises (Bakery), Haco industries, Kuguru foods, Farm engineering industries (Bwisa, 2004).

the theory may be limited in explaining why the majority of subsistence/ survivalist enterprises have stagnated and failed to grow (the missing middle phenomenon), and why the mortality rates in the MSE sector are so high.

2.2.6 Diffusion of innovations theory[16]

According to Caniels, Romijn and Ruijter (2004), the innovation process is linear, beginning with research, which is followed by development. Development leads to production and finally marketing. The theory of innovation[17] explains how and why new ideas spread through cultures. The classification scheme for adopters of innovative technology follows five categories, namely: (1) innovators or technology enthusiasts (venturesome, educated, multiple information sources), (2) early adopters or visionaries (social leaders, popular, educated), (3) early majority or pragmatists (deliberate, many informal contracts), (4) late majority or conservatives (skeptical, traditional, lower socio-economic status), and (5) laggards or skeptics (neighbours and friends are the main information sources, fear of debts).

This theory explains the change in customers as technology matures. In the early days, the innovators drive the markets by demanding technology. In the latter stages, the pragmatists and conservatives dominate. Although the innovators drive the technology markets, they are a small percentage of the market; the big market is with the pragmatists and conservatives.

[16] This section draws on <http://en.wikipenda.org/wiki/ Diffusion_of_innovations>

[17] It is important to note that innovation is either demand-led (based on social needs and market requirements) or supply-pushed (based on new technological possibilities). Most revolutionary innovations are the product of research and development, while more incremental innovations arise from the less formal on-the-job modifications of practice.

2.2.7 Synthesis of theories

The six theories reviewed above highlight important lessons for technology development within the MSE sector. One of the key lessons is that technology development and diffusion, and therefore competitiveness, is accelerated when MSEs operate in sector-specific clusters. This supports the viewpoint that accessing, using and developing technology has a spatial dimension and is perfected in an environment of flexible specialization and where collective effort is involved. The next lesson is that technology development is dynamic and requires the establishment of support infrastructure as the firms take stock of lessons learned from the introduction phase leading eventually to obsolescence. This calls for careful planning for replacement of dated technology.

The third lesson is that regardless of the source of innovation (whether supply-pushed or demand-led), technology diffusion is more effective when markets are present and when there is a pool of entrepreneurial individuals who are ready to take advantage of technology in responding to market signals. The competitiveness of such "techno-entrepreneurs" gives them the incentive to remain on the "technology frontier". This identifies the need to develop deliberate policies of identifying the few techno-entrepreneurs in high technology firms that will act as drivers of technology change. The final lesson is that the stimulus for technology change is either internal or external. Therefore, firms/countries should consider their internal capacity to invent and innovate new products and their capacity to absorb technologies developed elsewhere.

3. Status of Technology in Kenya

3.1 Review of Existing Policy

The purpose of this section is to review policy documents that have relevance for technology as it relates to MSEs. For this purpose, the main sources of reference include:

(1) Sessional Paper No. 5 of 1982 on *Science and Technology for Development* (Government of Kenya, 1982);

(2) Sessional Paper No. 1 of 1986 on *Economic Management for Renewed Growth (*Government of Kenya, *1986)*,

(3) Sessional Paper No. 2 of 1992 on *Small Enterprises and Jua Kali Development in Kenya (*Government of Kenya*, 1992);*

(4) Eighth National Development Plan 1997-2001 on *Rapid Industrialization for Sustainable Developmen*t (Government of Kenya, 1997);

(5) The Economic Recovery Strategy for Wealth and Employment Creation (ERSWEC) (Government of Kenya, 2003), and;

(6) Sessional Paper No. 2 of 2005 on *Development of Micro and Small Enterprises for Wealth and Employment Creation for Poverty Reduction* (Government of Kenya, 2005).

Sessional Paper No. 5 of 1982 was a response to the statutory mandate of the National Council for Science and Technology of "advising the Government on a national science and technology policy". The paper identifies industry as one of the areas where research is either weak or conspicuously absent and singles out SMEs as one of the key sectors of industrial policy thrust. It proposes to use financial incentives, and legislation to forestall the problem of weak research. It also proposes to develop a capacity for: (i) the development, acquisition, transfer and adaptation of technology; (ii) assessment, unpackaging and regulation of technology transferred to Kenya; (iii) control of standards for manufactured goods, and equipment; (iv) maintenance of plant, equipment and instrumentation; (v) engineering and industrial designs for the organization and modification of industrial processes and products; (vi) manufacture of and replacement of spare parts; (vii) export of intermediate and manufactured goods; and (ix) facilitating technological transformation. To the extent that the paper makes general policy statements, the paper seems to ignore the fact that technology needs of MSEs may not necessarily be similar to those of medium and large enterprises.

Given the overriding Government goal of economic liberalization, the main policy focus of Sessional Paper No. 1 of 1986 towards MSEs was to encourage market-based interventions. It shifted focus away from the Government's interventionist policy towards the facilitative role of creating infrastructural facilities and the economic environment for business. Following trade liberalization, there were expectations of a rise in import competition and domestic competition, particularly for MSEs. In response, the Government devised the following strategies to cushion MSEs.

First, it encouraged technical institutes and relevant institutions to develop simple goods and production techniques that would replace imported manufactures. Second, it proposed measures to disseminate information on new products and production methods to potential producers. Third, the Government saw the need to issue new regulations on tendering so that Government agencies would be compelled to give preferential treatment to bids from MSEs. Fourth, the Government was to revise building codes to favour architectural and engineering structures that make intensive use of products supplied by MSEs, with special attention towards low-cost housing models; and, lastly, the Government encouraged the formation of cooperatives as a means through which MSEs would access information and support on technologies, credit, inputs and markets. The main problem with the recommendations of this paper is that most of them remain unimplemented.

The Sessional Paper No. 2 of 1992 spelt out policies to enhance technology capacity within MSEs by encouraging research and development, linkages between small and large enterprises (through sub-contracting) and support institutions involved in technology development and diffusion. Specifically, the following measures were proposed:

1) Orient Kenya Industrial Research Development Institute (KIRDI) to assume additional responsibilities for modifying and adapting foreign technologies.

2) Establish a machine tool industry in the private sector—to encourage production-related technologies.

3) Use the public procurement procedure and regulations to support MSEs to find market for their products in the public sector.

4) Encourage collaborative research between KIRDI, universities and relevant ministries to identify technology research needs of the small enterprise sector and thereafter, design appropriate technology models for dissemination and adoption.

Further, the eighth National Development Plan identified the need to improve the product quality of MSEs and exporters. This was to be achieved, in part, by setting up district-based business information exchange centers, identifying technological and workforce requirements of the sector, and directing more resources to institutions that support *jua kali* technologies.

Some of the measures stipulated in the Sessional Paper No. 2 of 1997 to improve access to technology and information include establishing well defined means of transferring technology and information to entrepreneurs (Ronge, Ndirangu and Nyangito, 2002). It was also the intention of Government to promote extension services of R&D institutions such as KIRDI and local universities. Finally, the Sessional Paper provided for the establishment of the Technology Development Grants System as a strategy of linking R&D institutions and *jua kali* enterprises.

The National Council for Science and Technology, established under the Science and Technology Act (Cap 250), has been in the process of formulating an industrial technology policy to build local technology capacity and culture, provide guidelines on technological development choice, transfer and adoption, strengthen and streamline institutional linkages and encourage the participation of the private sector in developing industrial policy (Kimuyu, 1999).

The ERSWEC (Government of Kenya, 2003) promises to institutionalize the business incubation concept as a way of enhancing the linkages between the small and large segments of the business sector and improving the image and visibility of the MSE sector.

The Sessional Paper No. 2 of 2005 is more elaborate and comes up with various interventions. These can be categorized into four clusters, namely: (i) Ability to adapt and adopt new technology, (ii) Enhance the capacity of institutions that support technology development, (iii) Increase the access to information on available technology, and (iv) Provide technological skills. To address the problem of weak technology transfer mechanisms, the Government will review the current modes of technology acquisition and transfer into the country, define laws and provide legislation that would: (a) regulate and promote local and international technology transfer; (b) encourage partnerships through sub-contracting, franchising and licensing; and (c) vet and register imported technologies to discourage dumping of obsolete and/or dangerous technologies, which hinder innovation.

Further, the Government will provide technological input into the sector through importation of relevant technologies from middle-income economies such as India, South Korea, Pakistan and Bangladesh. In addition, the Government will provide waiver of duty on basic engineering machines and diversify technological innovation, research and development to cater for the needs of all MSEs. Further, the Government will encourage the commercialization of technology and viable innovations.

In the area of capacity utilization, technology transfer and diffusion in technology support institutions, the Government commits itself to strengthening linkages (cutting across MSEs, universities, technical institutions and research bodies), and creating awareness on available scientific and technological support services. The problem of low spending on research and development will be addressed by establishing an MSE Technology Development Fund.

Concerns over poor use of existing systems of intellectual property system will be remedied by enhancing their creativity and capacity to innovate, supported by establishment of award schemes for innovators. Further, business incubators will be established to support new businesses during start-ups and early growth phase.

The paper seeks to address the problem of low skill levels by enhancing the capacity of Technical Training Institutions, MSE Training and Demonstration Centers, Youth Polytechnics and National Youth Service skills development centers to offer appropriate skills to MSEs. Similarly, the capacity of Rural Technology Development Centers will be strengthened and collaborative arrangements for attachments for trainees in universities, tertiary technical training institutes will be supported.

Despite the above policy pronouncements by Government, we concur with Aduda and Kaane (1999) to argue that most of the policy proposals were not implemented. First, most MSEs still experience problems related to limited access to technological information and technical services and limited skills in technology management. Second, their operating environment is characterized by dysfunctional innovation systems and weak linkages between MSEs and medium and large enterprises. Third, the country has failed to design a vision on technology for MSEs. Finally, MSEs are constrained by underdeveloped entrepreneurial skills, limited access to appropriate technology and limited access to electricity.

3.2 Technological Support Institutions

There are many institutions providing industrial technology extension and technical training in Kenya. Other institutions originate technology policy and play an oversight role whereas others develop general policies on MSEs. These institutions range from government and quasi-Government to voluntary bodies. It is important that these institutions work together for smooth coordination of technological activities in the country.

3.2.1 Ministry of Labour and Human Resource Development

Government involvement in technology services for MSE is usually justified on the basis of the perceived market failure in technology markets (Oyeyinka, undated). In Kenya, the Department for Micro and Small Enterprise Development (MSED) in the Ministry of Labour and Human Resource Development (MLHRD)[18] was established to

[18] Whereas some MSE policy issues are executed by the Ministry, policy issues on SMEs fall within the mandate of Ministry of Trade and Industry. Supervision of the institutes of technology falls under the Ministry of Education, Science and Technology.

coordinate MSE activities. Technology support services offered by the Department include training and skills upgrading; engaging research and development institutions to re-orient their technology to the needs of MSEs; strengthening linkages between MSEs and large enterprises, universities and technical institutes and voluntary bodies; and improvement in adaptation of imported technology and consultancy services (Aduda, undated).

3.2.2 National Council for Science and Technology

According to the Science and Technology Act (Cap 250) of 1977, which established the National Council for Science and Technology (NCST), the responsibilities that fall under NCST's mandate include:

- Determining priorities for scientific and technological activities in Kenya;
- Advising the Government on a national science policy including general planning and the assessment of the requisite financial resources;
- Ensuring the application of the results of scientific activities to the development of agriculture, industry and social welfare;
- Advising the Government on the scientific and technological requirements for the conservation of the natural and social environment;
- Ensuring cooperation and coordination between the various agencies involved in making the national science policy;
- Advising on all scientific activities that entail application of the results of research; transfer of technology into agriculture and industry; scientific and technical manpower; scientific and research technology funding; science education at all levels; and

scientific documentation, statistics, surveys and general information, among others;

- Advising on suitable organizational arrangements for planning, managing and coordination of scientific activities and setting up of new research committees, research councils, establishments and technical services;
- Advising the Government on the overall financial requirements for the implementation of the national science policy and advising on the programmes and budgets for the promotion of the research and related scientific activities;
- Carrying out independent or joint surveys and investigations as the Council may consider necessary for its tasks; and
- Sponsoring national and international scientific conferences and establishing relationships with corresponding scientific organizations in other countries.

Several public research institutions were established under the Science and Technology Act (Cap 250) of 1979. These include Kenya Agricultural Research Institute (KARI); Kenya Medical Research Institute (KEMRI); Kenya Trypanosomiasis Research Institute (KETRI); Kenya Forestry Research Institute (KEMFRI); and Kenya Industrial Research and Development Institute (KIRDI). Over time, there has been changes that have affected these institutions. For instance, KETRI was merged with KARI in year 2003 in order to make it more efficient and effective.

Although the NCST was established to assess and advise on the adequacy of scientific and technological research and development carried out in the country, it mainly engages in research for its own sake and its links with industry are extremely weak. Very little marketing or commercialization of the research output is done, and small enterprises have limited access to information on the research carried out. Access is also limited by its location in Nairobi.

3.2.3 Kenya Industrial Research Development Institute

Since its establishment in 1979, Kenya Industrial Research Development Institute (KIRDI) has been offering technology related extension services to small and medium manufacturing firms in terms of industrial training, consultancy services, product testing for quality assurance, information gathering, processing and dissemination and advisory services. The Institute is mandated by the Science and Technology Act (Cap 250) to conduct research in the following areas (a) civil and chemical engineering, (b) electronics, (c) mechanical engineering, (d) textiles, (e) fibers, (f) ceramics, (g) clays, (h) foods, (i) chemicals, (j) mining and, (k) the development of power resources. Therefore, KIRDI was created to upgrade Kenya's technological and scientific capability, enhance technology transfer, adapt technology and disseminate good technology practices to local entrepreneurs (Kimuyu, 1999). The main functions of KIRDI include[19]:

- Identify and develop process and product technologies appropriate for the country's domestic market and export potential;
- Facilitate replacement of imported inputs with domestic ones;
- Aid and hasten transfer of technology through design development and adaptation of machinery, tools, equipment, instruments, and processes suitable for introduction in the country;

[19] See Ikiara (1988).

- Reduce the environmental problems deriving from indistrial wastes and effluents by devising appropriate treatment or recovery methods;
- Establish pilot plants to demonstrate the operation and effectiveness of some industrial technologies developed through efforts of the Institute;
- Provide industrial consultancy services to Kenyan manufacturers and to help in the commercialization of research findings; and
- Raise local technological capability in order to facilitate exploitation of the country's resource potential;

Some of the achievements that the Institute has made over the years include extraction of essential oils, sorghum-based weaning products, cassava-based products, food processing equipment, leather from fish skin and so on. The Institute has established specialized facilities such as Leather Development Center, Engineering Development Center, National Industrial Information Center, Traditional Foods Development Center and the National Cleaner Production Center. Despite these achievements, the Institute's activities are limited by lack of market-oriented research and development activities, low funding levels, inability to attract high caliber staff, weak linkages between RTOs and MSEs, on one hand, and between the RTOs on the other hand.

3.2.4 Kenya Bureau of Standards

The Kenya Bureau of Standards (KEBS) is a statutory regulatory body, established by an Act of Parliament in 1974. It is responsible for promoting and enforcing the adoption of standards in industry and commerce with a view to improving quality, industrial efficiency and productivity, and after-sales support services and all aspects of quality assurance.

The KEBS is mandated by the Act to perform the following activities: (1) Standards Development, (2) Product Certification (Issuance of Diamond Mark of Quality), (3) Quality System Certification (ISO 9000/ 14000 registration), (4) Hazard Analysis and Critical Control Points (HACCP) system Certification (Codex HACCP Principles 1997), (5) Laboratory testing services, (6) Assistance of implementation of standards, (7) Metrology and calibration, (8) Quality inspection of imports at ports of entry, (9) Training programmes and technical assistance.

In relation to MSEs, KEBS has supported the sector in the following ways. First, KEBS carries out quality assurance activities free of charge to entrepreneurs who have established production businesses in which they give free consultancy and technical advise. Quality assurance officers also pick samples of the products for testing and issue test certificates to the manufacturers at no costs. This is in line with the implementation of Kenya standards. Second, KEBS has a number of laboratories which test both food and non-food products to establish the quality of these products. Some modest fee is charged for testing services.

Third, KEBS carries out training and advisory services on both Kenya and international standards. This can be done for groups of specific sectors at a cost of Ksh 40,000 per day. In the past, this was done in collaboration with donor organizations, who sponsored training for specific groups in different sectors. Fourth, KEBS has established an annual Kenya Quality Awards Scheme. There is a special category for MSE competitors. Fifth, the product certification scheme offered by KEBS helps MSE products to be more competitive in the market as well as assisting in making the products to easily access and penetrate the regional markets. The permit to use the Diamond Mark in this scheme is charged at Ksh 55,000 per year.

3.2.5 Kenya Industrial Property Institute

The Kenya Industrial Property Office (KIPO) was established in 1990, through Industrial Property Act (Cap 509) as a department of the Ministry of Research, Technical Training and Technology. The Kenya Industrial Property Institute was established by the Industrial Property Act 2001 as a parastatal, to succeed the Kenya Industrial Property Office. The main functions of the Institute include: (1) examining applications and granting industrial property rights, including patents, industrial designs and utility models; (2) Screening technology transfer agreements and licenses; (3) disseminating patent information to the public; (4) promoting inventiveness and innovation; (5) instituting infringement proceedings in relation to industrial property rights; and (6) registering and renewing trade marks and service marks.

Industrial property in Kenya is administered by the Industrial Property Act 2001 whose mandate includes processing of patents, trademarks, service marks, industrial designs and utility models. Two things are worth noting. First, laws on protection of geographical indications and layout of integrated circuits are yet to be finalized. Second, there are certain aspects of intellectual property that fall outside the mandate of KIPI. Copyright is administered by the Copyright Board of Kenya under the Copyright Act 2001. The Plant Varieties Act is administered by the Kenya Plant Health Inspectorate Services (KEPHIS).

3.2.6 NGOs and international organizations

Several NGOs (Non-governmental organizations) are involved in enhancing the capacity of MSEs to create, adapt and use technology. The most prominent in this area include ApproTEC and Intermediate Technology Development Group (ITDG). At the international level, the prominent ones are the African Center for Technology Studies (ACTS) and Africa Technology Policy Studies Network (ATPS). ITDG promotes the use of appropriate technology by providing training in production to small-scale manufactures. AproTEC intervenes in this area through (a) research, design and development of technologies with potential for small enterprise creation; (b) training of manufacturers, new entrepreneurs, artisans and end users to manufacture and/or use appropriate technologies; and (c) advocacy and promotion of proven new technologies.

The ACTS and ATPS are somewhat involved in research and technology dissemination. Although international research centres help in solving national research and technological problems, most of their research priorities may not necessarily reflect immediate national development priorities. Such centers were founded to cater for a cluster of countries with similar problems. Their level and reliability in funding is often impressive as is their manpower base and equipment. Kenya benefits through training opportunities, collaboration in programmes and shared facilities and through interaction between the scientists.

A major hindrance to the performance of the technology-related institutions is their low funding levels. This arises out of the over-reliance of government resources. With the proposed creation of an MSE Technology Development Fund there is need to target resources from the private sector and development partners to increase funding for technology-related institutions.

3.3 Empirical Evidence

Following Archibugi and Coco (2004), we disaggregate technological capability into creation and use of technology, technology infrastructure and development of human skills. This categorization is adopted in sections 3.3.1, 3.3.2 and 3.3.3. Similarly, the section highlights the status of technology transfer in the MSE sector.

3.3.1 Creation and use of technology

Since technology is a key source of growth and competitiveness (WEF, 2004), firms that are able to access, generate and apply technology have a competitive edge over those that can not. The ability to use new technology is best captured by the production and investment capabilities whereas the ability to invent or innovate new technologies is captured by innovative capability (section 2.1.1).

Technology indicators presented in annex table 1 reveal that in terms of technology readiness[20], Kenya fairs better than countries such as Uganda and Tanzania. However, the statistics show that the country lags behind countries that have performed better in terms of technology effort as it relates to MSEs. Compared against the best performers (South Africa, Singapore, Brazil, Mauritius, UK and USA), Kenya's productive and investment capability is constrained by factors such as high cost of importing equipment, shortages of machine components and parts, limited availability of process machinery, and relatively low sophistication of production processes. Other constraints are related to relatively lower levels of firm-level technology absorption.

Out of 104 countries, Kenya is ranked 67th in terms of the capacity for innovation with a score of 2.9 (which falls below the mean score of 3.5) (WEF, 2004). This implies that Kenya's capacity for innovation falls below the global average. According to innovation indicators presented in annex table 2, this low capacity is attributable to low incentives for R&D, weak university-industry linkages, inadequate supply of technical personnel, and low priority by government of ICT. These constraints notwithstanding, the country has competitive advantages in the areas

[20]According to WEF (2004), technology readiness (as contrasted against innovation, which measures the level of introduction of new ideas, goods and services) measures the ability to access and use new technology.

of FDI-associated technology transfer, prevalence of foreign technology licensing, quality of scientific research institutions and firm-level spending on R&D. It can be argued that the paucity of local innovations makes the country rely more on foreign technology (through FDI and licensing).

Further, evidence indicates that although many firms in Kenya are capital intensive, they use outdated[21] capital stock (World Bank, 2004a). Among MSEs, there is evidence that enterprises use recycled and reconditioned tools and equipment[22] (Neshamba, undated). In addition, the practice of purchasing old machines and adapting them to their production requirements is prevalent within the MSE sector. In Kenya, small enterprises report lower capital and labour productivities relative to larger enterprises (Table 1). However, all enterprises experienced lower capital productivity relative to labour productivity. Most of these outcomes are traceable to the low levels of technological development and low capital/labour ratios in the MSE sector (Haan, 1999).

A study by Oyeyinka (undated) comparing sources, types, nature and limitations of technology support system between Kenya, Zimbabwe and Nigeria found that the main sources of technical information[23] for Kenyan SMEs were industrial associations (59.3%) and machinery supplier's (53.7%). Others were raw material suppliers, trade fairs, and government research and development institutions. Most SMEs rated private sources of technical information much higher than they did

[21]These are also called third/fourth generation technologies (Aduda and Kaane, 1999).

[22] Note that the age of capital stock is likely to be correlated with the modernity of the technology. Newer equipment is less likely to break down and interrupt production (Biggs, Shah and Srivastava, 1995).

[23] Ngahu (1995) found that over 64 per cent of the respondents acquired information on technologies through friends. The key method for technology choice in these enterprises was imitation.

Table 1: Labour and capital productivity by firm size

	Micro		Small		Medium		Large and very Large		All	
	Labour	Capital	Labour	Capital	Labour	Capital	Labour	Capital	Labour	Capital
Kenya	-	-	2.4	0.3	4.1	0.5	4.1	0.3	3.5	0.4
Tanzania	1.0	1.3	1.5	0.4	3.3	0.6	3.5	0.3	2.1	0.4
Uganda	0.6	0.8	0.9	0.7	1.4	0.4	3.3	0.9	1.1	0.7
India	3.1	0.8	2.9	1.1	3.2	1.5	5.3	1.2	3.4	1.1
China	1.9	0.1	4.6	0.6	4.8	0.7	4.2	0.5	4.4	0.5

Note (1) Labour productivity is measured as manufacturing value added per worker (in 000s US$) for the medium firm.

(2) Capital productivity is measured as the ratio of manufacturing value added to capital for the median firm.

(3) Micro refers to firms employing less than 10 persons, small (10-49 employees), medium (50-99 employees) and large and very large (above 100 employees).

Source: World Bank (2004a)

public sources. In the same study, Kenyan SMEs indicated that they solved their major technical and raw material problems through in-house innovation (50%) and consulting local maintenance organizations (72%).

Beyene (2002) citing an ECA (2001) study on technology and marketing support services in 13 African countries indicates that Kenya is one of the nine countries that provide technology support services—with four countries having no programmes for support services. However, these services were found to be wanting and institutional coordination was low. Regarding technology service needs, Aduda (undated) found that SME manufacturing firms in Kenya require a number of technology services. Such requirements varied across the enterprise sizes and by the gender of the owner. All SMEs indicated that they needed advice on market information. Female entrepreneurs indicated that they faced critical constraints in marketing, maintenance of tools and equipment, and linkages with other firms. The needs for firm owners of medium sized firms included establishing linkages with research and development bodies, linkages to universities, linkages to polytechnics and environmental management.

A recent study by Namusonge (2005) investigated the role of development financial institutions in either hindering or enhancing the acquisition of technological capabilities in SMEs in Kenya. Results indicate that the main channels through which DFI's enhance technological capability are through production and investment channels. On production and investment capability, there was evidence that Kenya Industrial Estate (KIE) supported MSEs through provision of skills and knowledge, repairs and maintenance of machinery, provision of initial and working capital and conducting feasibility studies for potential clients. The Industrial and Commerce Development Corporation (ICDC) supported MSEs to enhance their technological capabilities through provision of machinery, establishment of lines of credit with foreign partners (therefore allowing its clients to procure goods and services from abroad). ICDC also provides working capital to clients, finances market research and assists in the purchase of machinery and installation. Overall, about 84 percent and 74 percent of the respondents had been assisted by KIE to enhance their production and investment capabilities, respectively.

3.3.2 Technological infrastructures

Internet penetration: The debate on whether to adopt labour-intensive or capital-intensive technologies is no longer relevant—the world has changed to knowledge-based technologies (Aduda and Kaane, 1999). Internet is a vital infrastructure not only for business purposes, but also for access to knowledge (Archibugi and Coco, 2004). It has revolutionalized the ability to collect, analyze and transmit data and information. Firms are using the Internet to make contacts, to check prices, display goods and enter into contracts. Despite all these benefits, evidence seems to suggest that information technology may not necessarily empower MSEs due to problems related to access, low penetration rates, poor access to electricity and power and the fear of marginalization (Moyi, 2003).

Compared to Uganda and Tanzania, Kenya seems to perform better in terms of Internet penetration (Annex table 3). Similarly, compared against the levels of Internet hosts and users in South Africa, Singapore, Brazil, Mauritius, UK and USA, Kenya ranks very poorly and lags behind the world leaders.

Electricity and telephone: Electricity power consumption is the oldest indicator of technological infrastructure as it can be used to proxy the use of machinery and equipment (Archibugi and Coco, 2004). It is now recognized that most modern technologies are based on electricity

Table 2: Electricity and telephone access by MSEs

	Electricity (%)			Telephone (%)		
	Have access	No access	Total	Have access	No access	Total
Location						
Urban	56.5	43.5	100	36.4	63.6	100
Rural	23.4	76.6	100	18.1	81.9	100
All	49.3	50.7	100	32.4	67.2	100
Type of ownership						
Men	50.1	49.9	100	33.2	66.8	100
Women	45.3	54.7	100	30.7	69.3	100
Jointly owned	49.2	50.8	100	36.0	64.0	100
All	49.2	50.8	100	32.3	67.7	100

Note: Access to electricity and telephone was defined as the availability of the service on the worksite. This should be contrasted against the availability of the service inside the premises. Availability of the service on the worksite does not necessarily mean the availability of the service within the premises. Had this been the case, the percentages reported of the enterprises accessing the services would have been much lower than reported

Source: National Baseline Survey 1999 (CBS, K-Rep, and ICEG, 1999).

(Aduda and Kaane, 1999). Evidence indicates that over half of the MSEs operate on worksites that have no electricity (Table 2). In addition, all urban enterprises cited power interruptions as a severe constraint (CBS, K-Rep and ICEG, 1999). There are gender and location differences with regard to access to electricity—a large proportion of urban (relative to rural) and male-owned (relative to female-owned) enterprises have access to electricity.

In terms of telephone, almost one third of the MSEs have access to telephone. Rural enterprises have less access to telephone compared to urban enterprises. Similarly, female-owned enterprises have less access to telephone compared to male-owned enterprises. It is also clear that MSEs have better access to electricity than telephone.

Additional results (Annex table 3) indicate that telephone penetration is not only low but also that the quality of electricity supply and telephone supply is relatively poor. Despite these shortcomings, Kenya

Table 3: Structure of the TVET system in Kenya

Institutions	Level of training	Estimated capacity
Ministry of Education		
National polytechnics 1 technical teachers training college 21 technical training tnstitutes 16 institutes of technology	Diploma/Technician Diploma/Technician TEP Craft Certificat TEP Craft Certificate	26,000
Ministry of Labour		
1 Vocational Training Center Skills Centers Special Vocational Training Centers Kenya Textile Training Institute 600 Youth Polytechnics	TEP Artisan Certificate	45,000
15 Other Government Ministries		
40 Training Institutions	Mixed	Data unavailable 4,000 (est)
Private Sector, Churches, NGOs		
Estimated 800	Mixed	Data unavailable 80,000 (est.)

Source: World Bank (2004b)

has higher telephone penetration in the region (compared to Uganda and Tanzania).

3.3.3 Development of human skills

An important prerequisite of technology capability building is a labour force, which can select, install, maintain, assimilate, design, manufacture and even create technology (Huq, 1999). In Kenya, this professional cadre consists of artisans, craftsmen, technicians, technologists and engineers trained in the vocational and technical institutions (TVET) and at universities. Table 3 provides some indicators of the TVET system in Kenya.

Despite the expansion of the TVET system in Kenya over the years, the TVET system has been constrained by several factors (Government of Kenya, 2002; World Bank, 2004b). First, there is lack of a coherent national strategy and a focused policy framework. There are multiple ministries dealing with different aspects of TVET. This has resulted in poor coordination, overlapping functions, confusion over roles and functions. Second, most of the public training institutions have experienced lower enrolment capacity and effectiveness due to under-investment and policy neglect. They have obsolete facilities, equipment, curriculum, instructional capacity and quality.

Third, although many firms have lost confidence in public training institutions, the role of the private sector in providing TVET has not been adequately tapped. Fourth, the links between industry and public training institutions (through support for apprenticeship and attachment training, curriculum development and sponsorship) are very limited. Fifth, the skill needs of MSEs are not being adequately met by the existing TVET system. The statutory apprenticeship scheme, which was an important source of skills for the informal sector, is practically not functioning. Similarly, Youth Polytechnics (YPs) (a major source of skills for school leavers) are under-funded. For instance, by 2003, out of 600 YPs under the Ministry of Labour and Human Resource Development, around 40 percent of them did not receive financial support and were supported either by NGOs, churches or through "harambee".

3.3.4 Technology transfer

Following the definition of technology in section 2.1.1, technology transfer can be defined as the process that allows techniques, knowledge as well as products and organization/management practices (that embody technology) to flow from one entity or locus (a firm, region or country) to another entity. Technology transfer can either be through formal or informal methods (Ikiara, Moyi and Ogbu, forthcoming). Formal means of technology transfer include acquisition of capital equipment and machinery through trade, licensing (and/or franchising or distribution) agreements through which skills, ideas and technical information are transferred and through movement of experts and skilled labour. Informal technology transfer occurs mainly through non-market transactions via technology spillovers (demonstration-imitation effects, competition or labour turnover), printed information, observations during visits to foreign plants and so on.

Although estimating the extent of technology transfer, especially through informal sources, is difficult, there is evidence that MSEs are continually engaged in adapting industrial equipment for their own use and self constructing tools and equipment (Haan, 1999). One of the main methods used for technology choice in MSEs is through simple imitation based on observation (Ngahu, 1995; Haan, 1999). In addition, there is evidence that other informal sources of information, such as friends, are important (more than 64 percent of the respondents indicated that friends were the main source of information on available technologies).

Manufacturing MSEs source their technology either from local sources or from abroad (Moyi, 2001 and Ngahu, 1995)[24], although firms on the lower end of the size spectrum tend to rely more on locally available technologies than firms on the upper end of the size spectrum. Usually, the local sources of technology are limited in several ways. Evidence indicates that over 60 percent MSEs are dissatisfied with the technology they use and about 90 percent are desirous to enhance their innovative capacity (Aduda and Kaane, 1999).

[24]For instance, in a 1992 study of 140 SSEs in the carpentry and haircare sub-sectors in Kenya, Ngahu (1995) found that most tools and equipment used in the two sub sectors were imported. A limited survey of 25 owner managers (from manufacturing, trade, transport and construction industries) revealed that almost all the machine tools used in the manufacturing and production processes were second-hand, but their source of origin was foreign (Neshamba, undated).

Table 4: Source of manufacturing technology

	Micro	Small	Medium	All
Foreign, direct	6.9	5.9	30.8	10.5
Foreign, indirect	3.4	8.8	7.7	6.6
Local, formal	48.3	50.0	53.8	50.0
Local, informal	41.4	35.3	7.7	32.9

Source: Moyi (2001)

On the basis of Table 4, it can be argued that MSEs rely on both formal and informal means of technology transfer. They use both locally available technologies as well as foreign technologies, although the local sources are more commonly used. This implies that technology transfer occurs through machines and equipment. A study on industrial technology extension and technical training among 200 manufacturing SMEs by Aduda (undated) reveals that Kenya's SMEs technology is mostly embodied in form of tools, equipment and machinery with little industrial engineering. The only disembodied technology is in form of licensing, consultancy and management. The study argues that SMEs accessibility to government technology extension services is limited due their informality or lack of official registration[25] and their low educational achievement[26]. Low educational achievement leads to a general failure of most SME proprietors to appreciate the role of technology in production processes, product quality and market competitiveness. Even where they develop interest in new technology,

[25] Only 37 percent of the studied firms were registered with the Registrar of Companies. Majority of SMEs were not members to any trade association. Only about 20 percent of the SMEs were registered with trade associations or NGOs.

[26] About 56 percent of the owners and 80 percent of the employees of MSEs had only attained primary and secondary education.

Table 5: Support services to MSEs

	Do you provide service to members?						Are you aware of any other support services within the MSE Sector?					
	Yes		No		All		Yes		No		All	
	N	%	N	%	N	%	N	%	N	%	N	%
Technology	42	22.0	149	78.0	191	100	67	34.4	128	65.6	195	100
Marketing	61	31.4	133	68.6	194	100	67	34.4	128	65.6	195	100
Workspace	84	43.1	111	56.9	195	100	108	55.7	86	44.3	194	100

Note: "N" is the number of respondents.

Source: Moyi (forthcoming)

their limited education adversely affects the absorption capacity of acquired technology.

Results from an ILO supported Farm Implements and Tools programme (Haan, 1999) on exchange visits[27] indicate that the visits resulted in the introduction of new products, transfer of production technologies, purchase and repair of relevant equipment, improved group dynamics and collective enterprise management. The visits opened up opportunities for MSEs to extend their business networks: new contacts were established with peer producers and also with equipment suppliers and repairers and various MSE support organizations.

3.3.5 Role of MSE associations

The literature (Bennet, 1998; Helmsing, 2000) identifies MSE associations an effective channel of providing technology services by responding to member's individual and specific demands by strengthening the capability required to monitor and respond to technological and market changes. The associations also: (1) disseminate and enforce a stock of

[27] This refers to an organized way in which small producers pay a visit to pre-selected peers to exchange information on technologies and information on equipment use, suppliers of equipment and materials, market prices, marketing channels etc.

common quality, standards, rules and norms; (2) disseminate technical knowledge within the sector; (3) provide a forum for technological learning; and (4) they function as channels through which local producers acquire crucial tacit knowledge for local adaptation, either directly or indirectly.

Table 5 indicates that a small proportion of MSE associations provided technology services to members. Similarly, very few respondents were aware of any other support services for technology within the sector. One of the reasons to explain this may be the objectives of the associations. Most of them are formed for social welfare rather than to advance business interests of the MSEs. Again, even those associations that were formed with the objective of providing technical services, most have limited capacity to provide technological support services to MSEs.

Further results (Moyi, forthcoming) indicate that support services for technology are less effective. The associations were required to rank the effectiveness of the support services that they were aware of in the MSE sector. Regarding technology, about 56.4 percent, 35.9 percent and 7.7 percent of the respondents indicated that the level of effectiveness was low, moderate and high, respectively.

3.4 Summary of Issues on Technology

In terms of policy on technology for MSEs, the government has made several interventions and explicit policy pronouncements since 1986. Despite this, MSEs are still constrained by limited access to technological information and technical services and limited skills in technology management. The country lacks a national, coherent and comprehensive science, technology and innovation policy to guide decision making and the Science and Technology Act is outdated (over 20 years old) and fails to take into account current developments in the areas of information technology and biotechnology. MSEs operate in environments where there are dysfunctional innovation systems and weak linkages between MSEs and medium and large enterprises. Similarly, MSEs are constrained by underdeveloped entrepreneurial skills, limited access to appropriate technology and limited access to key technology infrastructures (power and electricity). Although the country has put in place several technological support institutions, coordination of technology support services is weak and the linkages between some of these institutions with MSEs remains questionable.

Kenya lags behind many other countries in technological progress. The World Competitiveness Report 2004-2005 (World Economic Forum, 2004) ranks Kenya in position 75 out of 104 countries on the basis of the technology competitiveness index. In terms of innovation, Kenya is ranked in position 87 out of 104. Although Kenya has made significant achievements in the agricultural sector through R&D investments, achievements in the industrial sector have been limited due to low funding levels for industrial research. This translates to low capability for industrial technologies, making the country a net importer of foreign technologies.

On the question of technological capabilities, MSEs are constrained by high costs of importing equipment, shortages of machine components and parts, limited availability of process machinery and relatively low sophistication of production processes. The firms' innovation capacity is low due to low incentives for R&D, weak linkages between MSEs and KIRDI, and inadequate supply of technical personnel. The weak technological capabilities explain the prevalence of outdated capital stock, recycled tools and equipment in the MSE sector.

Technology transfer in the sector is mainly through purchase of plant, machinery, tools and equipment. Other modes include through training, labour turnovers and factory visits. The most documented informal channel of technology transfer is through imitation. There is limited evidence on the role of licensing as a channel of technology transfer among MSEs. Therefore, much more work is needed to understand the role of licensing in MSE technological development.

4. Case Study Analysis

Countries have applied varying approaches to issues of technology. This section reviews seven country case studies with a view to highlighting best practices as far as the ability to create, acquire and adapt new technologies as a source of MSE competitiveness is concerned.

4.1 Botswana

This information is extracted from Chanda's (1999) case study of the "Technology Transfer Programme – TTP - in Botswana"[28]. The programme is co-ordinated by the Rural Industries Innovation Center (RIIC). The RIIC was established in 1975 but began operations in 1997. It is funded by the Government of Botswana (98%) and other donors (2%). The RIIC was established with the mandate to identify, adapt or develop technologies geared to employment creation and use of renewable energy. It also provides training to increase rural productivity.

Since the inception of the TTP, in 1998, a total of 28 SMEs have been sub-contracted to manufacture RICC technologies. Out of the 28 SMEs, 8 are participating in the TTP. About 50 different technologies have been developed or adapted by RIIC since the organization was set up. The most successful technologies developed by RIIC have been the sorghum milling equipment (dehuller and hummermill) and baking equipment (Kgotetso oven and rim oven).

The RIIC identifies, adapts or develops technologies in line with the research programmes and needs assessment surveys. The two ways used by RIIC to acquire small-scale technologies are development and adaptation. The main role of SMEs in this process is to manufacture for sale by RIIC the technologies that have been developed or adapted.

[28] Downloadable at <http://library.fes.de/fulltext/bueros/botswana/00554002.htm>

Technology development

Technology design: Product design specifications are compiled after the approval of the feasibility study report. Although all the specifications seek to address the identified needs, only the best specification is selected after an evaluation. The selected conceptual design is optimized and developed into a detailed design. The outputs of a detailed design are detailed design drawings that identify material specifications for both bought-in-components and processed components. These technical drawings are then passed on to the research and development workshop for the manufacture of a prototype.

Prototype manufacture: Once the prototype has been manufactured, trials are conducted to ensure that it satisfies the product design specifications. This is done prior to subjecting the prototype to any prolonged tests. Once the prototype has passed the trials, test parameters (to test for durability, performance, user acceptance and safety) for further testing are drawn up.

Prototype testing: The test parameters are used to prepare a test plan. The plan outlines the methodology to be followed during testing in order to achieve the objectives as set out by the test parameters. After testing, a report is prepared, which specifies whether or not the product has satisfied the test objectives. The report also suggests how the product can be modified to improve its performance. The report is reviewed and approved by representatives from internal sections. After the approval, a design package is prepared.

Design Package: The design package, comprised of the following documents and hardware, is then forwarded to the Technology Transfer Unit[29]: (a) an approved test report; (b) a set of drawings for the

[29] The Technology Transfer Unit coordinates the commercial manufacture of all RIIC developed or adapted technologies through sub-contracting to local engineering metal SMMEs as explained under technology manufacture

technology; (c) a set of jigs, templates and fixtures for use in the manufacture of the product to help simplify the production process of some of the parts and ensure uniformity of the same; (d) a sample of the technology; (e) a bill of quantities which gives the production cost of the technology; (f) technological process sheets; (g) an operators manual, which shows the capacity of the technology and how it should be operated.

Technology adaptation

This involves the identification of technologies for adaptation and is based on the research programmes of RIIC and the needs as identified by the needs assessment survey. The methods used to identify technologies for adaptation include literature surveys, country visits and attendance at international trade fairs.

Once the technology has been identified, it is evaluated to establish: (a) its mode of operation and potential to satisfy the identified need; (b) availability of manufacturing and servicing facilities in the country; (c) its compliance to national standards; and (d) legal implications.

After evaluation, one unit of the technology is purchased for testing from the organization manufacturing or promoting that particular technology. On receipt of the technology, test parameters are prepared and the testing is done as outlined under technology development. If the technology satisfies the test parameters, a design package is prepared (as outlined under technology development) for hand-over to the Technology Transfer Unit for commercial manufacture through sub-contracting to local engineering metal SMEs.

Technology manufacture

The manufacture of technologies developed or adapted by RIIC is done through the TTP. The programme is run and co-coordinated by the Technology Transfer Unit and involves identifying SMEs with the potential to manufacture these technologies, evaluating and listing them, and then sub-contracting them to manufacture these technologies for promotion and sale by RICC.

Problems encountered

Two major problems experienced during the transfer of the manufacturing know-how of RIIC technologies are: (1) high turnover of staff in the SMEs over a period of time, hence the training has to be repeated for the new staff; and (2) lack of proper business and production management skills resulting in high manufacturing costs and failure to meet delivery dates.

Benefits of the TTP

One of the benefits of the TTP has been to improve the innovative capacity of SMEs. The SMEs have been involved in making improvements to existing technologies by simplifying the manufacturing processes and therefore reducing production costs. They have also been involved in enhancing the performance of the existing technology. A case in point is that of sorghum dehuller and hammermill. These products were initially developed by RIIC but were improved significantly with the assistance of one SME. Another benefit of the TTP is that of maintaining existing jobs and creating job opportunities through the contracting of SMEs to manufacture RIIC technologies. Similarly, the programme enhances the manufacturing capacities of the SMEs through the transfer of the manufacturing know-how. It also creates the manufacturing capacity and repair facilities in the country for RIIC products and other related technologies.

4.2 South Africa[30]

In South Africa, the technopreneur programme strives to create sustainable enterprise through quality training and support services. Its specific objectives are to: promote access to technology and appropriate skills transfer; establish appropriate support systems; facilitate business start-up; and, to create sustainable enterprises through quality training. The technopreneur programme involves a number of strategic partners in the provinces. During 1998-1999, the programme was carried out by 14 institutions in 7 provinces. The technopreneur programme involves:

Needs analysis
Institutions identify gaps in their local community and business markets to customize the business training spheres.

Orientation process
Potential students are given an overview of the courses and their objectives.

Selection process
Successful applicants are given career guidance in choosing viable courses that are suited to their abilities and desires.

Training process
Access to technology and appropriate skills transfer integrated with business and entrepreneurial skills training.

Cocoon phase
After successful completion, the students are placed in small businesses under the guidance of the training institutions. Each student is afforded the opportunity to apply the skills and knowledge acquired during the training phase.

Mentoring phase
Students in this phase start-up their own businesses with diminished supportfrom the institution until the student becomes independent.

[30] The study draws on Beyene (2002).

To provide the trainee easy access to markets, the training institution negotiates contracts, such as supply repair, within the vicinity. Once the trainee has gone through the training process, s/he participates in a production operation to complete a particular contract in the field of training with support in the cocoon phase. Once the student has completed the last phase of the training, the future entrepreneur is introduced to the Technopreneur Start-up procedures.

Some of the technological infrastructures to support the technopreneurs includes the Manufacturing Advisory Centers (MACs), the Agricultural Research Council (ARC) and the Center for Industrial and Scientific Research (CISR). The MACs are established at regional levels to assist SME manufacturers to improve their productivity and competitiveness in the market place. The ARC assists in facilitating and guiding the process, whereby the small-scale farming sector, processing entrepreneur, and related industry entrepreneurs are serviced with appropriate new or existing technology. It also assists in the creation of awareness of both producers and consumers of the various products, services and new opportunities. Areas of possible assistance include product development, market analysis, feasibility studies and business plans and implementation assistance.

The CISR has recently launched initiatives in support of SMEs, which include:

- The Incubator for the Empowerment and job creation, which helps to develop SMEs to implement CISR-developed technologies to empower entrepreneurs from previously disadvantaged communities;
- The Environment Support Center, launched in the North Western Province to support both prospective and existing SMEs in technical extension, training, technology demonstration, administration and mentorship services; and

- Partnership with Ntiska Promotion Enterprise and the National Productivity Institute in launching Manufacturing Advisory Centers pilot programme aimed at assisting SME manufacturers to upgrade their performance and competitiveness in both local and international markets.

4.3 Mauritius

This case study draws on Beyene (2002). The study provides evidence of how improved Government support services have enhanced the competitiveness of SMEs. Mauritius has developed a sophisticated research infrastructure for its sugar industry, but there has not been much progress in R&D in other areas. Investment in R&D has been nearly only 0.01 percent of GDP compared to 0.6 percent in Singapore and 1.8 per cent in Korea.

The Small and Medium Industries Development Organization (SMIDO), the Export Processing Zones Development Authority (EPZDA) and the Industrial and Vocational Training Board (IVTB) are major players in extending support services in technology and skills development.

The SMIDO aspires to create a strong and modern SME sector that is efficient, competitive, integrated and increasingly export-oriented. Only SMEs in manufacturing have access to SMIDO. It has mapped out various key thrusts to support its mission: Productivity and export promotion, entrepreneurship development and start-up services, technology application, quality development, training and consultancy, incentive management and regional SME development. The technical services center is based on the concept of the common facilities workshop. It is equipped with a variety of workshop machinery to undertake the various operations to help small enterprises in the repair and maintenance of their production system wherever possible. It also provides, among other things, Product and Process Development Grant which covers up to 50 percent of the nominal cost associated with consultancy, production equipment and investment costs on prototypes, in relation to the development of either new processes or products.

The SMIDO gives short duration training programmes to upgrade technical skills of entrepreneurs in areas such as workshop organization and machine operation (lathe, milling, drilling, gear cutting, welding, etc). The Center also disseminates new technology and helps modernizing SMEs by providing advice as to the best technology available for their specific business. It helps to fabricate parts for SMEs and to provide repairs and maintenance service. Between June 1997 and 1998, the Center manufactured 225 parts for 130 enterprises.

The EPZA, established in 1992, provides a range of services to EPZ firms so as to enable them to improve their competitiveness. It primarily focuses on the small exporter and its services are targeted at the textile sector. Its service offerings include: consultancy services through the Textile Technology Center – CTC. CTC has 'state-of-the-art' equipment, constantly being updated to ensure the latest world-wide developments are available to be seen and to be used by the Center. The EPZA also offers its services through a trend forum, which occasionally organizes seminars and workshops, exhibitions and buyers/sellers meetings in the area of textiles, etc.

The IVTB complements the activities undertaken by SMIDO and EPZDA. There is a government training levy of 1 percent on the wage bills of enterprises and is administered by IVTB. When enterprises engage in any type of training, they are refunded 80 percent of the cost, provided the training is carried out in the context of approved programmes and institutions. Even training given at SMIDO gets refunded when the enterprises send their employees for approved training course at SMIDO. IVTB has training centers and is assisted by 90 private training institutions. In addition to the training services it provides, IVTB renders technical advice and runs library and information services.

4.4 Singapore

In the area of technology, Singapore is ranked in position 11 out of 103 countries (World Economic Forum, 2004). The country is known for success in attracting high-tech multinationals, university/industry research collaboration, technology readiness, higher firm-level spending on R&D, higher technology absorption at the firm level, prevalence of foreign technology licensing, production process sophistication, and so on (Annex tables 1, 2, and 3). Within this context, the country has evolved an elaborate support system (Local Industry Upgrading Programme - LIUP) for manufacturing MSEs[31]. Central to this support system is an indigenous technical capability upgrading system.

The upgrading programme was consolidated under MSE master plan and presented by Economic Development Board ((EDB), a government body in 1989. It aims at strengthening local manufacturers' internal technological capabilities by improving their increased operational efficiency and the ability to perform incremental improvements in products and processes. The idea is to raise MSEs technical standards to a level where they compete with leading foreign suppliers and in that way form attractive partners with large local Transnational Corporations (TNC).

The design of the programme is demand-led and makes use of buyer mentoring. The EDB, acting as a network broker, approaches TNCs to participate in the projects and on agreement, an engineer from the TNC moves to EDB as a LIUP manager for 2-3 years with a responsibility of identifying areas of focused assistance for the TNC suppliers. A

[31] This case study draws on Romijn (2001).

participating TNC takes on a number of MSEs and provides training in management, quality control, process engineering and industrial engineering through visits, workshops and consulting services. The EDB on its part makes a variety of financial support schemes accessible to participating MSEs.

Inbuilt into the programme is an incentive structure that ensures that 90 percent of costs that the transnational corporations (TNCs) incur are taken up by the government through provision of subsidies. Participating MSEs also bear part of the costs. The success of the programme hinges on the fact that benefits are mutual and market forces, rather than compulsion, motivate the technology transfers.

Overall, the impacts of the programme are evident from: (1) successful technological learning through direct know how transfers; (2) learning through feedback provided by stringent quality/performance control by trans-nationals; and (3) investment in capital equipment by small firms.

4.5 Brazil

This case study reviews the technical upgrading of MSEs through public procurement[32]. It involves a public procurement scheme for school furniture. The local government, in conjunction with the SME support agency SEBRAE, was influential in promoting the development of a local woodworking cluster (Nadvi, 1995). The programme is demand driven as it resulted from the government action to open up public procurement, creating a potential market for basic manufactured basic products from the SMEs.

[32] This case study draws on Romijn (2001).

The SMEs were required to upgrade their technology as a prerequisite of meeting the production standards. The SEBRAE offers technical support and consulting service to help SMEs raise their internal technological capacity. The customer-driven approach led to a well-focused and efficient form of assistance in which producers could learn in an incremental fashion. As SMEs in the project keep hitting bottlenecks to fulfill government procurement standards, they call on SEBRAE engineers.

This programme was narrowly targeted to a small collection of clustered small enterprises in one locality operating in one activity. This approach had advantages of large orders, which could not be satisfied by the production capacity of one individual, therefore making it more practical to contract small enterprises as a group. An association for this group was responsible for ensuring product quality and honoring warranties, orders and claims in case of default. The formation of an association facilitated collective group learning, as they had to collaborate to solve common problems.

The design of the incentive scheme within the programme was key to the technological upgrading of the enterprises. Two important features mimicked the way in which private markets work and they set up tremendous pressure on the technical assistance deliverers and beneficiaries to perform. First, was the new potential market that was created (public contracts) but the customer was not obliged to proceed with the procurement from the small enterprises if they did not meet the quality standards of regular large scale suppliers. This had the effect of creating a scheme based on competition between small and large enterprises. The fact that the technical assisting body received commission based on successful securing of orders by producers meant its financial position was dependent upon the effectiveness by which it delivered the assistance.

The impact of the programme is evident from:

- Upgraded skills
- Knowledge and management capabilities of enterprises
- Investment in power tools (the number of saw mills in the town rose from four to 42)
- Creation of backward and forward linkages
- Increased employment (total employment in the sector from 12 to over 1000) in the industry locally
- About 70 percent of the output from participating MSEs was already going to private sector in a span of five years.

4.6 United Kingdom

In the UK, dynamic networks of regionally clustered small and micro enterprise have emerged in the recent past and are promising to boost local economic competitiveness. Through a case study of 33 small software development and electronics manufacturing companies in South England, Romijn and Albu (2001) elicited information about innovative performance and the range of factors that may have contributed to the performance. The study examined the link between innovations, inputs and outputs. Despite the limitation of small sample size, the study provided useful insights into the driving force behind innovation in high technology micro and small-enterprises.

In analyzing innovativeness and its main sources in SMEs, firm level technology advancement is conceptualized in terms of the learning process. Internal and external factors contribute to the build up of innovation capability. Entrepreneurs and the workforce bring into the firm certain stock of knowledge and skills obtained through earlier experience. Similarly, internal learning through investments in research and development, informal experimentation, making minor adaptations to products, process organization, and in-house staff training enhances the firm's capability.

Externally, interactions with suppliers, customers, public agencies, industry associations, and foundations provide an important missing input into the learning process, which the firm cannot self-provide. Interactions take part through external staff training, parts and components, consulting services, research and development. Regional clustering of networks of actors further boosts learning by interaction.

The case study points to the importance of government policy as an important input into innovativeness. The UK government moved to become a facilitator, particularly by promoting the formation of regional clusters. It contends that geographical proximity is a driving force to linkages and fostering a community of interests among high-tech SMEs. The government is using several policy instruments to stimulate innovative regional clusters of technology-intensive small firms. These policies include:

- Support policies intended to reduce barriers to access to capital markets, business advisory services and technological development. For instance, the government avails Innovation and Technology Counsellors to coordinate use of local resources of innovation.
- Promotion of science parks and business incubators targeted at exploiting geographical closeness. However, mere proximity may not work without creation of facilities that foster formation of informal community interactions.
- Policies that promote science, technology and innovation through financial support to research and development for promising projects in small firms.

Evidence indicates that prior experience in a research institute correlates highly with innovativeness. It finds that most of the founders of SMEs had extensive work experience in a research environment where they conceived the idea that resulted into establishing their small businesses. Therefore, the fact that the research took place in an environment with access to laboratory equipment and secure equipment indicates the importance to innovativeness in SMEs.

The findings establish a clear relationship between a firms' innovativeness performance and the total research and development resources (R&D) invested per employee. The intensity of research and development has a link with patents, and incidences of major product innovations.

The study finds that training activities were not reflected initially in higher capabilities of the firm. It argues that organizational capability is more than the sum total of individual learning as this depends on how effectively individuals communicate and work together in teams. However, interactions with national science bases like research laboratories and universities are likely to lead to major product innovations. Such innovations were found to be original and technically complex.

Frequent interactions with suppliers were also associated with strong incremental innovation rather than major innovation. The case study finds little support for the regional clustering strategy, which involves frequent interactions with government agencies, industry associations or training institutions.

4.7 United States

This study by Cordes, Hertzfeld and Vonortas (1999) was conducted in a sample of small firms in a set of high-technology sectors in order to understand the origins, finance, research and development, and other innovation activities of small firms in these sectors[33]. The survey gathered information on technology sources, research and development, research and experimentation (R&E) tax credit, intellectual property practices, technology alliances, innovations by type (product, process, service, management), market size, and market share of the innovations. One of the remarkable arguments in the study is that even though large businesses play a big role in industrial innovations, small firms[34] play a crucial role in the process by which technological ideas are commercialized.

Research and development effort: On research and development, the study found a high concentration of small R&D-intensive companies among the respondents to the survey. Half of the 177 firms reporting on R&D employees had employed one to four R&D personnel (full-time equivalent) during the previous year. Expenditure on R&D accounted for 3 percent of the annual sales for over two thirds of the firms. Majority of the R&D was undertaken inhouse.

Perceived competitive strategies: The majority of the respondents considered their competitive edge to relate more to product quality, strategic flexibility and quick reaction to customer needs, and to the speed of introducing new products, than to competition in terms of price. Product range, production cost, and product price were reportedly of relatively lesser importance in defining small firm comparative competitive advantage.

Strategies for introducing new innovations: The main strategy used by the respondents to introduce new technology involved either identifying

[33] These include not only firms that develop such technologies but also those firms that make regular use of these new technologies to produce their goods or deliver their services.

[34] Small firms are those with fewer than 500 employees.

specific market niches or being first to the market. The vast majority of the rest followed a first-to-the-market strategy. The vast majority of the innovators indicated that innovations had been developed internally. Factors listed as being particularly important in successfully introducing new products or processes include developing the necessary technology, marketing and engaging qualified technical personnel. Additional, but less important factors were securing adequate financing, intellectual property protection, distribution networks, acquiring necessary technology and production startup. Relatively unimportant factors (for the successful introduction of new products and processes) were training, government regulations/legislation and ease of obtaining a government export license.

Tax credits for research and experimentation: This tax incentive had a rather modest effect on the incentive of small firms to innovate. Most of the firms did not claim the credit either because they did not qualify due to low taxable income or because they had failed to exceed the base amount of R&D spending required. The study showed mixed effects of the credit. Over half of respondents believed the credit had no measurable effect on the firm. Some firms reported that the credit had stimulated them to increase R&D spending by an amount equal to or more than the amount of the credit.

Small Business Innovation Research Program (SBIRP)[35]*:* The study indicated that this programme had a modest, though measurable effect. About 34 per cent of the firms in the sample had submitted proposals for a Phase 1 SBIR and 24 percent had received a SBIR Phase 1 award. About 20 percent had submitted proposals for a Phase II SBIR and 16 percent had received an award.

[35] This is a programme where each participating federal agency competitively awards funding for research and development in small firms that have commercial potential. The awards are made in phases, with the second and third phase of funding tied directly to the potential for commercial applications.

Customers: The overwhelming majority of the respondents cited their customers to be a very important source for new ideas and technological knowledge. In addition to customers, sources internal to the firm were rated to be either important or very important by 74 percent of 174 respondents. This finding is consistent with prior findings in the literature. Small firms depend very much on their customers for incentives to innovate and for new ideas and technological knowledge. It is almost certain that, for a significant percentage of the smaller of these companies, customers means a small number of large, technically advanced corporations that buy a lot of their output and that regularly subcontract to them technically demanding jobs.

Competitor firms, suppliers and trade shows: Respondents were asked to rate, on a reducing scale, the importance of various sources for new ideas and technological information. Rated as less important were competitor firms, industrial shows, and suppliers. This was followed by trade publications, professional and scientific journals, professional societies and meetings, universities and colleges, and consultants. Finally, very few firms rated government laboratories, other government sources and publications, and non-profit organizations as very important sources of new ideas and technological knowledge.

Perhaps, the relatively poor rating of government laboratories and other government sources stands out in view of the widespread support for active government involvement in helping out industry with new technologies and technology transfer especially for the case of small firms. On the contrary, the government can be a significant buyer of the products of such firms and therefore help them grow, a role that various federal agencies have played successfully in the past.

Intellectual Property Protection (IPR): Informal, rather than formal, means of IPR protection was rated as being highly important. This result held true for both product and process innovations. Lead-time to market dominated all other means of intellectual property protection. Keeping trade secrets was rated behind lead-time as a strategy of protecting both product and process innovations. Patents were ranked behind both lead-time to market and trade secrets. Only half of the respondents rated patents as either important or very important in protecting intellectual property related to product innovations.

4.8 Summary and Lessons

On the basis of the case studies reviewed in this section, it is clear that technology support to MSEs can be delivered in different forms ranging from specific and targeted programme support to government policy directions. However, the following important lessons can be distilled from the above analysis:

- *Enhance public support:* This can take the form of direct subsidies (as in Singapore), affirmative policy in public procurement (as in Brazil) and through financial support to R&D (as in UK). In the US, firms are eligible for tax credits for research and experimentation, and to innovation research grants. In Mauritius, the Government runs product and Process Development Grants for the development of new processes or products.
- *Deepen market forces:* Demand-led approaches (through linking MSEs as suppliers and the consumers of their products; and undertaking needs assessments to identify technology gaps) are a better driver of MSEs technological processes. Therefore, it is critical to provide conducive business environments that encourage the deepening of input, intermediate products and output markets as well as technology markets (for instance, promoting innovation fairs).

- *Promote inter-firm technological transfers:* Linkages between technologically superior firms (e.g. TNCs) and technology laggards is an effective way of helping resource-constrained MSEs to access foreign technology.
- *Promote MSE clusters and associations:* Associations play the role of organizing MSEs so that they can increase their bargaining power. Associations can also act as intermediaries between individual business action and state action (Bennet, 1998). Clusters are known to enhance the collective efficiency of enterprises by allowing them to reap scale economies.
- *Enhance the role of metrology and standards:* In Mauritius, large firms had higher technological development scores mainly due to the pressure to conform to ISO 9000 standards. Limited knowledge of ISO certification limited technological development and competitiveness of SMEs.
- *Promote the establishment of technology parks and business incubators:* These institutions/organizations promote the link between the creators or suppliers of technology (universities and research institutes) and provide infrastructural support for innovation-based enterprises.
- *Promote research and development:* Most of the innovations are a product of research and development. Innovative and competitive firms spend a considerable proportion of their revenues on R&D. Alternatively, firms depend on publicly supplied research and development.
- *Encourage intellectual property protection:* IPRs aim to foster innovation in the private sector by allowing inventors to benefit from their inventions. Instruments of IPR such as patents,

copyrights, trademarks and trade secrets enhance competition and the working of technology markets.

- *Develop mentoring programmes for technopreneurs*: As highlighted by the diffusion of innovations theory (section 2.2.6), it is such technopreneurs that drive technology markets and lead to new ideas and innovations. Since such people are only a small proportion of the market, targeted programmes would include incubation and mentoring as an integral part.

5. Requisites of a Technology Model for Kenya

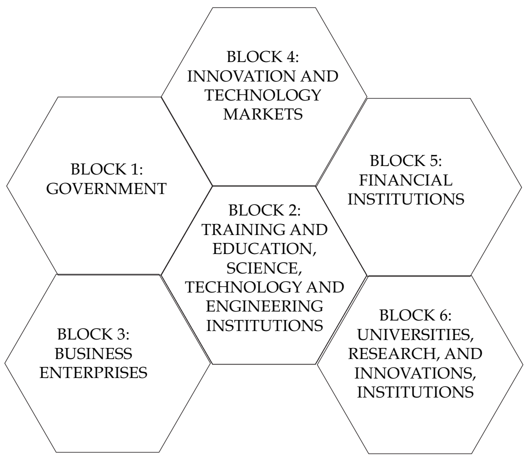
This section represents the main thrust of this study. It synthesizes sections 2, 3 and 4, which have analyzed the common principles and best practices in creating, transferring, adapting and using technology. Broadly, it is clear from the reviews that most successful approaches have followed an integrated approach linking several institutions, namely the Government, training institutions, business enterprises, financial institutions, research institutions and innovation markets (Figure 2). Before developing the model, we discuss the role of each of these pillars.

5.1 Building Blocks

Block 1 - The Government: The Government is charged with many functions. One of the most prominent is creating effective national systems of innovation. These include institutions and organizations that support invention, innovation, technology diffusion, transfer and adoption. These include public and private institutions involved in research and development as well as institutes that emphasize technology extension services. The Government is also charged with the role of developing a science and technology policy and in promoting science and technology planning. Similarly, the Government plays the role of establishing institutions to regulate technology including metrology, standards and intellectual property rights.

Similarly, it is the role of Government to encourage university linkage programmes by, for assistance, requiring a given proportion of new invention and innovations emanating from university science and research laboratory to focus on MSE technological development and providing incentives to university professors who collaborate with MSE in their research endeavors). The Government can create the environment for the development of organizations that provide technology information services. Such organizations would provide technical information in relatively disembodied form on effective technological practices for MSEs in various industries. The Government can improve technological performance through direct subsidies for technological innovation or technological mastery/deepening.

Figure 2: Building blocks of accelerated technological development



Similarly, MSES are dependent on good infrastructure for technological development, and the Government has to supply this. Some of the common infrastructural services include power, telephone and Internet. However, special purpose infrastructure for MSEs with the specific intent of improving technological performance include "enterprise incubators" (especially for technology-based enterprises) and "sites and services"[36].

Generally, market failures exist due to consumer's insufficient awareness on the supply of such goods and services, and the suppliers' parallel

[36] Examples are programmes servicing high technology enterprises by providing common resources such as computer, library, instrumentation, etc.

lack of understanding of the demand for such goods and services. Given this understanding, the Government is critical in developing markets to provide technological and related services.

The Government can also strengthen affirmative policies for MSEs. In the area of technology, the Government can require that technology-intensive goods and services be procured from MSEs or that prime contractors for such goods and services sub-contract with MSEs.

Blocks 2 and 6 - Science, Technology and Engineering Education Institutions: In Kenya, such institutions include universities, national polytechnics, technical training institutes, institutes of technology, vocational training centers, skills centers, textile training institute, youth polytechnics, etc. These institutions contribute to the building of skills and the transfer of technologies. They generate a stock of engineers, technologists, technicians, craftsmen and artisans who deal with the selection, installation, maintenance, assimilation, designing, manufacturing and creating technology.

Block 3 - Business Enterprises (MSEs): The business enterprise is where technical change augments the production process to transform inputs into outputs. It is at this point where the process of technological development leads to real output and where significant technological learning takes place. Therefore, enterprises, MSEs, medium and large enterprises can play a role in technological development of MSEs. The private sector can develop programmes that encourage business linkages and technology transfers between large enterprises and MSEs. Larger enterprises with international links can support MSEs to access franchising systems by developing policies and institutions to promote franchising.

The MSEs can organize themselves into associations. On theoretical grounds, the formation of business associations is justified by either state or market failure (Moyi, forthcoming). In the area of technology, associations can disseminate and enforce a stock of common quality (through quality councils), standards, rules and norms. They also disseminate technical knowledge within the sector by functioning as channels through which local producers acquire crucial tacit knowledge for local adaptation, either directly or indirectly. Similarly, associations can design loan guarantee programmes. Such programmes can be designed specifically to improve access to financing for technological activities of MSEs by providing guarantees for loans. Associations can also offer technology services directly to their members.

Block 4: Innovation and technology markets: In Kenya, there is little evidence of a technology market. It is necessary to increase awareness about the importance of shifting to other modes of production, based on a higher content of locally-produced inputs and capital goods, and relying more on local technological capacity. This should reduce dependence on imported tools and equipment, which many MSEs may not be able to afford, and which forces MSEs to use sub-standard or second-hand equipment. Innovation markets can be enhanced by: (i) organizing "innovation fairs"; (ii) raising awareness of the potential importance of innovation markets; (iii) enhancing industrial capacity to bring innovations to the production stage; and (iv) enforce intellectual property rights to protect entrepreneur's innovations.

Block 5: Most owners of MSEs face great difficulties in accessing loans from banks to enable them invest in new equipment because current micro credit schemes do not provide this. Current policies of the micro-finance and lending institutions should therefore be changed to accommodate the MSE sector.

5.2 Current Technology Model

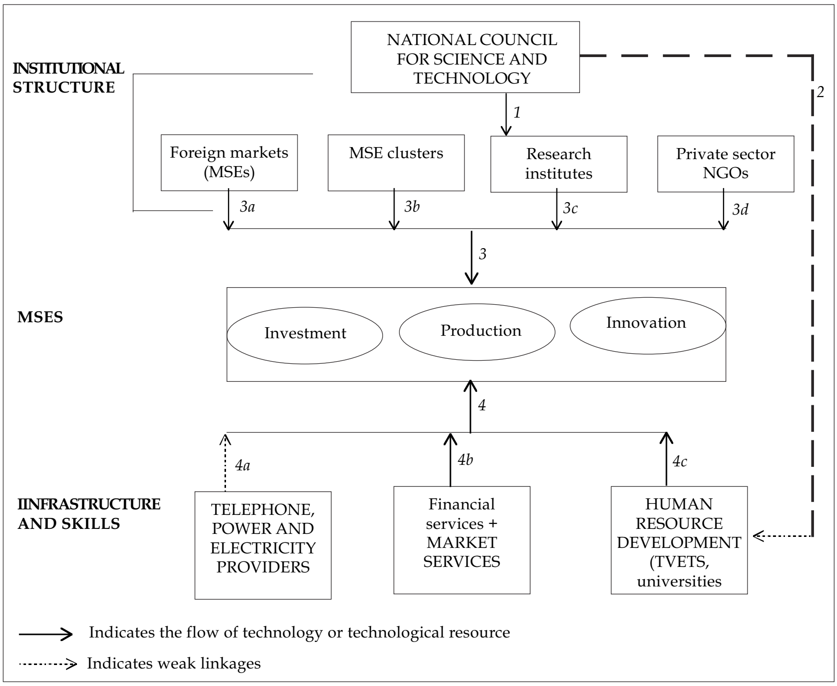
The current model of enhancing technological capabilities is presented in Figure 3. This model has been derived on the basis of the discussions in section 3.2 of this study. The main technological support institutions include the National Council for Science and Technology (NCST), Ministry of Labour and Human Resource Development, the private sector, NGOs, and KIRDI (see also section 3.2). The NCST is mainly responsible for technology policy design and regulation. However, the current science and technology policy (Sessional Paper No. 5 of 1982 on Science and Technology for Development) is outdated and does not address the specific technology concerns of MSEs. The main institutions that are closely linked to the NCST are the statutory research institutions including KIRDI (see arrow 1). The KIRDI also suffers from the problem of supply-driven (rather than demand-driven) research, and weak linkages between RTOs and MSEs, on one hand, and between RTOs, on the other hand.

Arrow 2 indicates that the NCST has weak linkages with training institutions and Ministry of Labour and Human Resource Development (MLHRD). This is unfortunate since the Council should regulate the technology curriculum to ensure that they conform to current trends. The council should also ensure that science and technology policy conforms to MSE priorities.

Arrows 3 (a, b, c and d) indicate that one way technology flows from some institutions to MSEs. These include technology transfer through multinational corporations (3a), through MSE clusters (3b), research institutes (3c) and private sector and NGOs (3d). Arrow 3e indicates that some technology flows take place from Technology Research Institutes to clusters of MSE but such flows are weak. The technology that is transferred to MSEs will enhance the investment, production and innovation capability of the MSEs.

The arrows marked 4 (a, b and c) indicate the role of infrastructure in enhancing the technological capability of MSEs. Arrow 4a indicates the role of power and electricity. It should be noted that this flow is weak

Figure 3: Current model of enhancing acquisition and transfer of technology



since most MSEs (50.8%) have no access to electricity and 67.7 percent have no access to a public telephone. Similarly, arrow 4b is weak since MSEs still experience significant credit constraints and their access to markets is severely limited. In fact, technology markets are completely absent. This implies that technology transactions can be at best non-commercial and informal. Arrow 4c is somehow stronger than the other two. This is because considerable resources have been invested in human resource development by Government, NGOs, and churches, etc.

5.3 Proposed Technology Model

The current model has several shortcomings and weaknesses. Some of these shortcomings are responsible for the poor state of technology in the MSEs sector. In Figure 4, we present the proposed framework for

MSE technology development. In this framework, the NCST will work closely with the yet to be formed National Council on Small Enterprise (NCSE)[37] to formulate technology policies for MSEs. Given the diverse MSE technology support agencies, associations and public bodies, the NCSE should be all inclusive. It is also critical that it be based on stakeholder representation principles and be autonomous of Government. This will, among other things, ensure a national collaborative approach to policy issues affecting the MSE sector, including technology. The policies originating from this would then provide specific regulations for technology from abroad (arrow 1a) and create an enabling environment for the operation of associations (1b) and strengthen networking among MSEs.

Similarly, the NCST and NCSE will provide incentives for private sector to invest in research and development and regulate technology extension services among NGOs (arrow 1c). Similarly, the NCST and NCSE will ensure that the technology priorities of MSEs are taken up by technology Research Institutes such as KIRDI (arrow 1e) by, among other things, undertaking technology capacity needs assessments and developing technologies to meet the identified needs. It will also be critical for the NCST and NCSE to liaise with KIPI and KEBS to formulate policies that educate MSEs on the role of intellectual property protection, quality, standards and metrology (arrow 1f).

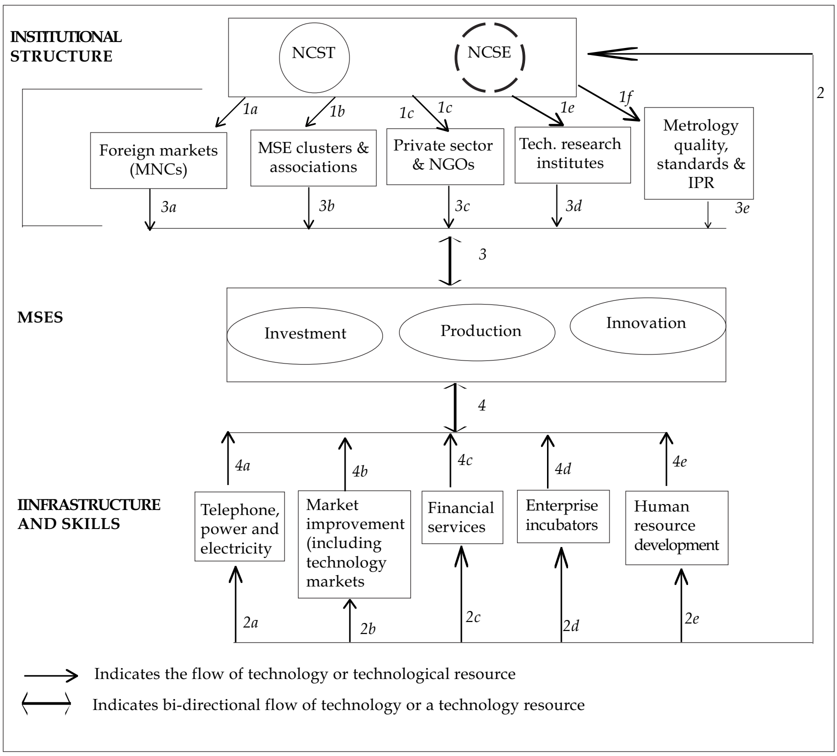
The arrows labeled 2 (a, b, c, d and e) indicate that the NCST and NCSE should also influence the provision of infrastructure (arrow 2a), market deepening (arrow 2b), develop policies for technological financial services (2c), enterprise incubators (arrow 2d), and the development of human resources (arrow 2e).

[37] The NCSE will be established once an MSE Act is enacted.

The contribution of MNCs (arrow 3a), MSE associations (arrow 3b), the private sector and NGOs (arrow 3c), technology research institutes (arrow 3d) and KEBS and KIPI in enhancing technological capabilities of MSEs are represented by arrow 3.

In the new model, telephone and power (arrow 4a) are critical in enhancing the technological capability. Preferably, programmes should be designed, modeled along the lines of rural electrification or micro-infrastructure, to cater for the unique needs of the MSE sector. Similarly, markets (input, intermediate goods, technology) should be developed and deepened. The efficient functioning of such markets enhances technological capability of MSEs (arrow 4b). Financial institutions are

Figure 4: Proposed model of enhancing acquisition and transfer of technology



also critical in enhancing technological capability of MSEs (arrow 4c). As indicated by Namusonge (2005), there is need to develop financial institutions as technology institutions in acquiring technological capabilities for MSEs. Similarly, technology parks and incubators should be established to create a direct link between creators of technology (universities and research institutes) and users of technology (MSEs) (arrow 4d). Technology parks and incubators provide infrastructural support for innovation-based enterprises. Arrow 4c represents the role of skills (of artisans, craftsmen, technologists, technicians and engineers) in enhancing technological capability among MSEs.

6. Conclusion

The main purpose of this study was to develop a theoretical model for MSEs in Kenya. We have attempted to do this by drawing lessons from case study evidence, empirics, theory and policy reviews. The model does not constitute a new policy framework neither does it serve the purpose of narrowing the gap between policy formulation and implementation. Rather, the model is intended to be a tool that could be used by MSE associations and other stakeholders to lobby for the implementation of MSE policies. The paper analyses the existing situation (policies, regulations, institutions and handicaps) and proposes changes in the institutional structure and infrastructure that are consistent with current policy stipulations. This is also in line with the objective of the KIPPRA-USAID MSE project (see section 1.1).

The model that we proposed, while seeking to enhance the creation, adaptation, acquisition, transfer and use of technology among MSEs (in the long run), is entirely theoretical and may not necessarily be easily amenable for use. However, it serves the crucial role of assisting policy analysts, researchers, practitioners, and MSEs to understand the MSE environment as it relates to technology and the linkages across the various players. To make it amenable for use, the model will be field tested and modified accordingly. It is on this basis that eventually a more refine empirical model will be developed and shared with stakeholders. Stakeholder views will further improve the empirical model. The improved empirical model will then be marketed to MSE associations for use by MSEs to lobby for implementation of MSE policies on technology.

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APPENDIX

Table 1: Creation of technology: Production and investment capability

	Kenya		Uganda		Tanzania		South Africa		Singapore		Brazil		Mauritius		UK		US	
	R	S	R	S	R	S	R	S	R	S	R	S	R	S	R	S	R	S
Technology readiness	68	3.3	79	2.9	80	2.8	32	4.5	8	5.9	36	4.3	55	3.8	17	5.3	2	6.5
Cost of importing foreign equipment	85	2.8	98	3.2	71	2.5	41	1.8	4	1.1	99	3.2	80	2.7	14	1.3	26	1.5
Local availability of components and parts	53	3.2	68	2.6	76	2.4	30	4.0	34	3.9	14	4.6	73	2.5	12	4.6	3	5.4
Local availability of process machinery	56	2.7	71	2.3	70	2.3	36	3.3	41	3.1	23	4.0	74	2.2	11	4.4	3	5.2
Local availability of specialized research and training services	57	3.9	46	4.2	72	3.6	21	5.0	20	5.0	17	5.1	77	3.5	4	6.0	1	6.4
Production process sophistication	86	2.8	94	2.5	76	3.0	37	4.1	11	5.7	31	4.3	55	3.7	16	5.4	5	6.0
Firm-level technology absorption	71	4.2	66	4.3	69	4.2	28	5.2	9	5.9	33	5.1	55	4.5	21	5.3	2	6.3

Notes: (a) This index was designed to capture the increase in business costs attributable to trade barriers in terms of import tariffs and quotas, license fees and bank fees (1=less than 10%, 2=11-20%, 3=21-30%, 4=41-60%, 5=61-75%, 6=76-100%, 7=more than 100%)

(b) R stands for the rank of a country out of 104 countries while S stands for the score of the country within a range of 1 (the lowest) and 7 (the highest).

Source: WEF (2004) World Competitiveness Report 2004 – 2005

Table 2: Creation of technology: Innovative capability

	Kenya		Uganda		Tanzania		South Africa		Singapore		Brazil		Mauritius		UK		US	
	R	S	R	S	R	S	R	S	R	S	R	S	R	S	R	S	R	S
FDI and technology transfer	18	5.3	17	5.3	31	5.1	22	5.3	1	6.3	42	4.9	50	4.7	19	5.3	78	4.3
Prevalence of foreign technology licensing	34	4.8	55	4.6	65	4.3	2	5.8	1	5.8	24	5.1	48	4.7	15	5.3	28	5.0
Quality of Scientific research institutions	31	4.4	33	4.4	45	3.9	27	4.5	13	5.2	37	4.3	57	3.7	5	5.8	1	6.3
Company spending on research and development	32	3.7	38	3.4	69	2.9	24	4.0	9	4.8	31	3.7	50	3.1	11	4.7	2	5.8
Subsidies and tax credits for firm-level research and development	67	2.7	41	3.3	46	3.2	39	3.3	1	5.5	40	3.3	54	2.9	11	4.6	16	4.5
University/Industry research collaboration	63	2.9	35	3.6	50	3.1	19	4.3	5	5.1	28	3.8	59	2.9	8	5.0	2	5.4
Availability of scientists and engineers	55	4.7	72	4.2	83	4.0	88	3.8	19	5.5	58	4.7	81	4.1	34	5.1	8	5.9
Government prioritization of ICT	69	4.0	32	4.9	49	4.5	41	4.8	1	6.1	54	4.4	4	5.8	28	5.0	20	5.2
Utility Patents, 2003	68	0.2	79	0.0	77	0.0	32	2.5	10	99.3	46	0.7	79	0.0	17	61.2	1	299
Capacity for innovation	67	2.9	62	3.0	95	2.4	42	3.5	18	4.6	37	3.7	59	3.1	10	5.4	7	5.8

Source: World Economic Forum (2004): World Competitiveness Report 2004-2005

Table 3: Technology infrastructure

	Kenya		Uganda		Tanzania		South Africa		Singapore		Brazil		Mauritius		UK		US	
	R	S	R	S	R	S	R	S	R	S	R	S	R	S	R	S	R	S
Quality of electricity supply	89	3.0	93	2.8	90	3.0	26	5.9	10	6.7	54	4.9	49	5.0	17	6.3	22	6.2
Telephone/fax infrastructure quality	95	3.4	72	5.0	79	4.7	70	5.1	6	6.8	35	6.3	65	5.4	19	6.6	27	6.5
Telephone lines, 2003	92	1.0	103	0.2	101	0.4	71	10.7	27	45	52	24	38	28.5	12	59.1	10	62.1
Property rights	68	4.2	83	3.5	82	3.6	21	5.9	12	6.3	47	4.8	46	4.8	1	6.6	13	6.3
Intellectual property protection	71	3.1	85	2.7	74	3.0	22	5.0	13	5.7	51	3.7	55	3.5	6	6.1	3	6.2
Internet users, 2003[38]	89	127	96	49	93	71	60	682	5	5481	57	822	48	1,229	17	4,231	4	5,514
Internet hosts, 2003	81	2.6	89	1.0	85	1.6	47	62.3	10	1,155	35	179	53	32.6	19	545	1	5,549

Source: World Economic Forum (2004): World Competitiveness Report 2004-2005

[38] This index is measured to indicate users per 10,000 inhabitants. The same applies to Internet hosts.