An Investigation into Factors that Influence the Diffusion and Adoption of Inventions and Innovations from Research Institutes and Universities in Kenya

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Abstract

This report presents findings of phase I of a two-phase research whose main concern is investigating factors which influence the diffusion and adoption or acceptability of inventions and innovations made by Kenya's publicly funded research and development institutions. Phase I of the research was carried out to study the supply and demand of inventions and innovations originating from Kenya's publicly funded institutions, namely, the public universities and research institutes, as well as the demand for such innovations by the users.

The overall objective of this research is to identify policy interventions that could assist the technological process of diffusing and adopting local inventions and innovations.

Glossary of Terms

technology The application of knowledge to the production and distribution of goods and services. Technology is the conversion process that transforms the inputs of a business into outputs. More than simply machinery, technology also includes knowledge, tools, techniques and actions that are necessary to complete the transformation process. Often viewed as a major source of environmental change for business, technology consists of both inventions and innovations.

invention The creation of a new product or service that did not exist before.

innovation The modification and/or adaptation of a product or service; the introduction of a process or product that is new only to the given environment regardless of whether it has been used before anywhere. We believe that in innovation, the alteration of a product, rather than the creation of a new one, is almost always involved.

technological innovations Innovations adopted by entrepreneurial entities, as either intermediate or capital goods. Those innovations adopted by households as consumer goods will be referred to as consumer innovations.

adoption The acceptance of an innovation or invention by at least one user.

diffusion The process by which an innovation or invention is communicated through certain channels to reach and be adopted by many users.

objective The result which is expected. Objectives are, therefore, the broad aims of organizations and are related to the future since their attainment is distant in time and must be carefully planned. Planning in its turn is taken to be effectiveonly when it is supported by a network of appropriate policies.

policy The body of principles laid down to underline and guide the activities of an organization towards the declared objectives. A policy, therefore, means specific guidelines, methods, procedures, rules, and administrative practices established to support and encourage work towards stated objectives. It sets boundaries, constraints and limits on the kinds of administrative actions that can be taken to reward and sanction behaviour; it clarifies what should and should not be done in pursuit of the set objectives.

research and development Any creative and systematic activity undertaken to increase the stock of innovations or technology.

I. Introduction

In Kenya, publicly funded research has been undertaken for over 50 years. In recognition of the role of organized research and development (R&D), the country has established a number of research institutions. There are, today, five public universities:

- The University of Nairobi (UoN) - the oldest
- Kenyatta University (KU) - once a constituent college of UoN
- Moi University
- Egerton University and,
- Jomo Kenyatta University of Agriculture and Technology (JKUAT) - the youngest and once a constituent college of KU.

There are a number of non-university academic institutions commonly referred to as middle level colleges, including national polytechnics, that undertake some research, particularly innovational research. There are also lower level polytechnics that run practical programmes in innovations.

The country has gone further to establish specialised non-academic research institutes to cover various sectors of the economy. These include:

- The Kenya Agricultural Research Institute (KARI) addresses problems in the sector of agriculture.
- The Kenya Industrial Research and Development Institute (KIRDI) addressesproblems in the industrial sector.
- The Kenya Medical Research Institute (KEMRI) for the improvement of the health sector.
- The Kenya Forest Research Institute (KEFRI) addresses forestry problems.
- The Kenya Marine and Fisheries Research Institute (KEMFRI) promotes the exploitation of marine resources and the development of inland fisheries.
- The Kenya Trypanosomiasis Research Institute (KETRI) researches the effects of the tsetse fly on livestock and humans.

In addition to these institutions there are two Commodity Research Foundations namely, the Coffee Research Foundation (CRF) and the Tea Research Foundation of Kenya (TRFK). But unlike the previously listed institutions, which are funded through the exchequer, the foundations are funded through cess from commodity sales.

Kenya has, therefore, built enough public capacity to innovate and invent technologies to be diffused and adopted into the national economy. Although there are no clear records, it would appear that initially (largely in the 1960s and early 1970s), much of

research in Kenya, especially from non-academic institutions, concentrated on identifying and developing primary commodities to substitute imported consumer goods. The results became readily public and seemed to serve the long-term national developmental process.

Things are not quite the same any more. General observations indicate that most of today's research findings remain unapplied. The growing concern in recent years that the results of publicly funded research should be fully exploited and the society should derive maximum benefit from them is quite justified. Our belief, when we started this research, was that innovation and improved technical change in Kenya's economy should be the goal of Kenya's research institutions. Such a goal may best be realized by a combined effort between the research institutions and the users of their results. We have not changed our minds on this.

In phase I we carried out case studies of four Kenyan institutions involved in technological research and of the intended recipients of their results. The nature and extent of influence exerted by selected factors upon the entire process of invention-innovation-adoption was examined.

If results from the studied institutions are anything to go by, then many research and development (R&D) institutions in Kenya could be operating with very little interaction with the users of their results. Indeed efforts to work out modalities on how the users of research results can be involved in R&D carried out at the public research institutions do not seem to have succeeded. This has led to two glaring consequences: 1) some innovations and inventions made by the institutions do not address the real needs of the intended users, and 2) very many of these innovations and inventions (including those that do address the user needs) are never known by their intended users.

The general public "hue and cry" that the major roadblock to these efforts is lack of an exhaustively articulated government policy to effectively assist in linking researchers to the users of their results is apparently justified.

Our phase I findings do point to possible science and R&D policy interventions and how they may be expected to influence user-oriented R&D. However, conclusive policy recommendations can only be made after the completion of phase II, which is supposed to unveil the magnitude of innovations and inventions made by publicly funded R&D institutions.

Results emanating from the two phases of this research will add value to the academic field of technology transfer and diffusion and also to the national technology policy formulation efforts. We are, for example, confident that the inventory of innovations and inventions that we shall make in phase II will guide researchers in Kenya to "the way ahead" in research. It will help them avoid duplicating research and its associated drain on public funds, throw light on which areas are over- and which under- researched and finally enable incremental research by providing information on which research needs to be done.

This will be of great national importance particularly at this time when the country's planners are thinking of putting more emphasis on research and development to assist Kenya become a newly industrialised country (NIC) by the year 2020.

II. The Research Problem

The bottom line of the research is that most of the research results originating from publicly funded institutions do not end up in the hands of the users. Research institutions have continued to operate in isolation producing results that can not be accepted (adopted) by or diffused to the users. The overall effect has been that the government has continued to fund research institutions whose activities have resulted in the development of products and processes which could have been useful to end users but have remained shelved. This ties up large amounts of public funds. An investigation into factors that influence the diffusion of research results constituted a real research problem.

Social, scientific and development relevance of the problem

The problem as outlined above has social, scientific and developmental relevance. This relevance can be summarised in the commonly aired phrase "Technology and Development".

Indeed, science and technology stand at the centre of many critical issues facing the development of any society. Countless theoretical and empirical investigations have emphasized the crucial role that innovation played in fostering the development of today's developed nations. The same process is now seen as crucial to Third World development. There is a recognition that attempts to borrow and transfer technology from the North have not stimulated Third World development as desired.

The situation has been made even more grave by the fact that many countries of the North have put in place protective measures, especially in the area of intellectual property rights, in order to protect their domestic industries. This means that technology transfer capable of building domestic technological capabilities by the recipient Third World countries is limited. That then seems to explain the present emphasis in most Third World countries on endogenous technical innovation. The Schumacher (1973) idea of appropriate technology has formed much of the basis of technology policy formulation in many less developed nations.

A common criticism levelled against many Third World governments is that they pay no more than lip service to the need for accelerated endogenous technological development. The abilities of their own citizens for technological innovation that leads to entrepreneurship have not been exhaustively harnessed.

Third World researchers have been criticised for not researching exhaustively the field of local diffusion of innovations. Yet diffusion research can provide a theoretical understanding of human behaviour and accelerate technological change. It is a fact that left on its own, technological change in a developing nation can be strongly affected by

pressure of international economic competition. But not all these pressures are favourable to the weaker competitor, i.e the third world. Any study of attributes of technology with a view of identifying ways of assisting third world technological policies has, therefore, developmental relevance. That this research aspires to identify roadblocks to adopting local innovations means that it has social and developmental relevance.

III. Literature Review

Problems with the diffusion of innovations are now widely recognised. Getting an idea adopted even when it has obvious advantages is often very difficult. A common problem for many inventors/innovators, which is not exhaustively researched, becomes the issue of how to speed up the rate of diffusion of inventions and innovations. In other words, it is the problem of how to bring about change – and in this case technical and/or technological change – which is largely at the core of the science and technology policies of many countries.

Schumpter (1950) identified three phases in the process of technical change, namely, invention, innovation and diffusion.

Invention

An invention is the creation of any new idea and so the term is not restricted to advances in science and technology (Glaister, 1989). Glaister stresses that although it is usual to think of invention as the creation of a new product involving scientific advances or new product processes, invention also includes developments that do not incorporate any scientific advance. We view this to mean that inventions can occur even in the less advanced nations.

Another view is that an invention is a process by which a new idea is discovered or created. Adjeberg-Asem (1988) points out that an invention is the initial stage of an innovation process with the other stage being the prototype. When the prototype is introduced to the market then the invention becomes an innovation.

To Rothwell and Zegveld (1983), an invention is an act of technical creativity that involves the description of a novel concept that could be patented. An invention is not an act suggesting movement toward commercial exploitation.

The International Bureau of World Intellectual Property Office (WIPO) defines invention as a new solution to a technical problem. The problem may be new or old but the solution, in order to merit the name invention must be a new one. The problem must be a technical one. The word technical has different meanings depending on the context in which it is used. In connection with inventions technical implies that the invention must have practical uses, particularly in industry. It enables industry to make new products, or to make products in a more economical way (faster, more cheaply etc) or to improve existing products by making them more precise and yielding better results.

Today inventions are rarely a result of an accidental or an instantaneous stroke of genius. They are increasingly becoming the result of long, systematic, hard thinking and experimentation with the precise aim and hope of arriving at a new solution amount-

ing to an invention. In other words most of today's inventions are a result of methodical research.

Thring and Laithwaite (1977) assert that an essential part of an invention is the strong desire to produce a better solution to a human need and the ability to understand through the hands and eyes the way things work in space and time.

This focus on the human need was extremely useful for our research. We therefore designed a questionnaire to investigate whether or not Kenyan inventors gear themselves towards known local problems or invention for the sake of it.

Innovation

Glaister (1989) defines innovation as the commercial exploitation of the invention. He asserts that innovation includes the whole process whereby technologies and products are brought to commercial fruition. Thus an invention may be a scientific discovery while innovation is its economic application.

Rogers (1983) defines innovation as an idea, practice or object that is perceived as new to an individual or another unit of adoption. Thus it is an innovation if perceived so by the user. The idea of commercialisation is echoed.

Adgeberg-Asem (1988) views innovation as the introduction of a technical or mechanical process involving:

- Either a potential market or a basic scientific idea;
- The ability to practicalize the need or idea;
- Concretization of the above by producing an invention and creating a prototype or adapting an old idea to a new use;
- Tests of the new invention or idea that shows it workable and acceptable; and
- The introduction, usually on a small scale, of the invention into a market place.

These five involvements are echoed by Rogers (1983) who identifies five characteristics of innovation as perceived by individuals as:

- Relative advantage i.e. how better the innovation is than the existing (or alternative);
- Compatibility i.e how consistent the innovation is with the existing values and norms;
- Complexity i.e how difficult it is to understand and use the innovation;
- Triability, i.e. how easy it is to experiment on the innovation; and
- Observability i.e how easy the results of the innovation are observable or visible to others.

Our interpretation is that innovation is actually a process starting with an invention. For the innovation process to continue beyond the stage of invention it seems logical that action must be taken to apply the invention in a way that results in its successful utilization. This may mean that the attributes listed by Rogers ought to be incorporated in the innovation. They seem to us to be key in determining the rate at which the innovation can be adopted by the users.

In our study, we investigated those attributes that do (or should) influence the diffusion of locally made innovations and inventions. Specifically we sought answers to the question "what is the driving force for innovations and inventions in Kenya". The two dominant models applied in literature to this question are known as technology push and demand pull (or innovation-oriented and client-oriented, or top-down and bottom-up).

The technology-push (innovation-oriented or top-down) model assumes that discoveries in basic science or research and development lead to innovations that can successfully find their way to the market place. This is very much like saying supply creates demand.

Apologetics to this model include Clark (1985), Freeman (1982), Mansfield (1978) and Minasian (1962). The last two demonstrate that spending on research and development is related to economic output. This side of the debate has found support in many third world countries' national science and technology budgets.

Many of these countries' budgets seem to imply that large expenditures on R & D *per se* can lead to progress. Thus a lot of academic research is being funded in institutions with results more often than not left to gather dust on the library shelves.

The demand pull model emphasizes the market need. It is a reverse argument to the above model and ideally suggests that demand creates supply. It has come as a recent reaction to the technology push model and is best advanced in the developed nations. Thus three-quarters of innovations in the U.S. scientific instruments industry originate with the user as is the case in the U.K. medical instrument industry (Adjeberg-Asem, 1988). Supporters of this model argue that the needs of the user and the feedback from him should play a leading role before and after the launch of innovations.

Studies that support this model include that of Rothwell and Gardiner (1985). The underlying concept here is that an innovation is primarily a commercial rather than a research activity.

The two models – technology-push and demand-pull – should be considered two extremes each having its pros and cons. In Kenya no work known to us suggests which is the dominant model. To bridge this gap, we designed a questionnaire to investigate how Kenyan innovations actually come about – technology-push or technology-pull?

Diffusion and adoption

By diffusion is understood the process by which an innovation is communicated through certain channels over time among members of a social system (Rogers, 1983; Adjeberg-Asem, 1988). The four elements of a diffusion process are, therefore, innovation, communication channels, time and the social system. Many technologists think that advantageous innovations would sell themselves, that the obvious benefits of a new idea would be widely realized by potential adopters, and that the innovation would therefore diffuse rapidly.

Unfortunately, this is very seldom the case. Most innovations, in fact, diffuse at surprisingly slow rates. Literature is full of examples. One very popularly quoted example is that of hybrid corn seed which, despite its known advantages, took a very long time to diffuse and be adopted.

When one peruses the diffusion research literature one is impressed by efforts ex-

pended on studying differences in innovativeness (that is, determining the characteristics of different adopter categories). Relatively little effort has been devoted to analyzing "innovation" differences (that is, investigating how the properties of an innovation affect its rate of diffusion and adoption). A study of the differences can be of great value to change agents seeking to predict the reactions of their clients to an innovation and if need be to modify certain of these reactions even by the way they name an innovation and relate the new idea to existing beliefs.

Communication channels and social structures have been found to be key actors in the process of diffusion. Both of them determine the speed of diffusion and adoption. Mass media channels have been found to be rapid and efficient means of informing an audience about an innovation. Established behaviour patterns that are part of a social structure have been found to define a range of tolerable behaviour and serve as a standard for members of the system in accepting an innovation, hence the impact on speed of diffusion. Our study borrowed from these established theories and investigated them with Kenyan innovations.

Factors influencing adoption/diffusion of innovations

The adoption and diffusion of inventions and innovations is apparently influenced by a variety of factors. Blackledge (1979) includes among the factors that inhibit the diffusion the following:

- the absence of technical economic feasibility studies,
- market analysis to assess the product or process potential,
- unwillingness of the users of technologies to take risks on unproven technology,
- lack of adequate financing mechanisms; and
- the institutes' lack of capabilities to transfer completed research results as a package acceptable to the entrepreneur.

The factor relating to the inadequate funding for research and development has also been echoed by Alhassan (1994). He goes further to add more technology transfer inhibiting factors.
These include poor institutional arrangements and inadequate links between developers and users of technologies. Alhassan sees the lack of pilot plant facilities as a major constraint in the process of "packaging" research results for commercialisation.

An enabling policy has also been sighted as a major factor in enhancing the adoption and diffusion of innovations. Banerjee (1992) argues that since development of inventions has to take place within the framework of the economic and political set-up of a country, this very set-up becomes a function of a country's research and development base for the successful diffusion of innovations. Yossifor (1992) concurs with this view and asserts that a variety of instruments are necessary for the fostering of an enabling policy. These include fiscal incentives, preferential financing and provision of venture capital.

The need for an enabling policy for the transfer of technology has also been stressed by Nichol (1992), who asserts that the three factors necessary for diffusion of innova-

tions are:

- information about technical feasibility;
- nformation about demand for a new process or product; and
- investment funds.

The success of a diffusion process requires that these three factors. The enabling policy should facilitate these factors, since an unbalanced provision may not bear the desired fruits. Our research explored the status of these factors in Kenya.

Institutional arrangements and the diffusion of inventions

Institutional arrangements have been explored by Su (1987). He suggests that institutions engaged in R&D should be encouraged to adopt contracts with user organizations that would not only enhance the flow of innovations but also ensure that research institutions are financially self-sufficient. Su notes that experience with contracts between research institutes and user organizations serves to solve a multitude of outstanding problems of R&D. First, efforts of R&D are directed to high priority areas of economic development. Second, the alienation among organizations is lessened promoting cooperation and exchange of personnel for better utilization of resources. Third, R&D personnel are motivated by pertinent remunerative measures for capable workers.

Using the U.S. example, Ku (1992) narrates how competitiveness, innovation and technology transfer as a government concern can be useful. She informs us that in 1970 the US Government realised that government-owned innovations were not being developed by industry. As a result, in 1980, Public Law 99-517, Patent and Trademark Law Amendment Act of 1980 was enacted. The law was designed to encourage US universities to set up their own technology transfer operations and resulted in extensive technology transfer efforts by universities. In 1980 alone there were about 65 members of a small organization called the Society of University Patent Administrators (SUPA). Virtually a decade thereafter in 1992 the same organization which had renamed itself the Association of University Technology Managers, amd had grown more than tenfold to a membership of over 650.

Bekoe (1993) discusses the problem of African national research systems placing undue concentration on research (basic or applied) without adequate attention to development. This, he argues, is due to few systematic mechanisms for converting research results into practical commercial activity. Bekoe suggests that mechanisms similar to the National Research Development Corporation (NRDC) of India that specialize in buying the risks of application of research results should be established in Africa. While carrying out this study we had in mind Kenya's institutional arrangements and how they may affect the diffusion of inventions and innovations.