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RESEARCH ARTICLE

ANALYSIS OF SCIENCE, TECHNOLOGY, AND INNOVATION POLICY AND ITS CHALLENGES IN ETHIOPIA; AN EMPHASIS ON THE ROLE OF HEIS

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ABSTRACT

Science, technology and innovation [henceforth 'STI'] policy has long been a key instrument for building national competitiveness and accelerating the socio-economic development of countries. The contribution of STI in improving the quality of people's lives has been enormous and indispensable. In relation to this, Ethiopia recognized the importance of STI long ago. It has therefore promulgated and revised its science, technology and innovation policy over the years. The STI policy which was issued in 2012 is designed in a way that serves as a key driver for inclusive and sustainable economic development. The main purpose of this study is to enhance understanding of the challenges of STI policy. The author examined the evolution of Ethiopian STI Policy and the challenges of its implementation. To achieve the objectives, empirical data was collected from both primary and secondary sources. Semi-structured interview was used to gather data from the subjects drawn from research council offices of three public universities and the Ministry of Science and Technology. In addition, document and archive reports were systematically reviewed. Clear indications of improvement and progress in the STI related endeavors were observed from the results of the study. However, there are implementation problems as evaluated from dimensions including technology transfer, research, triple helix framework, financing, and international cooperation. Likewise, results indicate that work needs to be done in formulating programs, guidelines and directives that facilitate policy translation into action. The paper ends by suggesting some recommendations for the actors in the STI policy.

INTRODUCTION

Moving upwards not only staying top on the global economy necessitates that a country excels in science, technology, and innovation. The stages of development of a country may vary depending on whether it is factor, efficiency, or innovation driven. Regardless of the stages, however, bringing about accelerated and sustained economic development in a country requires building scientific and technological capabilities. Ethiopia as an agrarian country has acknowledged the importance of Research and Development (R&D). As a result, it has established institutions and initiated the formulation of relevant policy frameworks to oversee and foster the production of new knowledge and the importation of existing foreign technologies in a way that improve the standard of living of the people.

Thus, main purpose of this paper is to enhance understanding of the challenges of STI policy (2012) in Ethiopia. The paper attempts to address the following two questions:

- How is the STI policy embracing the national development goal of the country?
- How are the (higher education institutions (HEIs) contributing to STI endeavors of the country?

Both primary and secondary sources were used in an effort to answer the aforementioned questions. The primary data was collected through a survey using semi-structured interview. The secondary data was collected through a systematic review of the policy documents. Furthermore, other published reports and materials were consulted to get a glimpse of recent trends and developments in STI activities in the country. Purposive sampling technique was adopted to select the three universities included in the study; Mekelle University, Addis Ababa University, and Gonder University. Furthermore, all the informants including the one from Ministry of Science and Technology (MoST) were carefully selected because they are familiar with the STI policy and related matters by virtue of their positions as research council officers. Qualitative data analysis technique was employed to analyze the data. Generalizations of the findings must be cautioned because of limitations number of subjects involved and HIEs included in addition to the obvious inherent methodological limitations of such types of the study.

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This paper is divided into three sections. Section one is dedicated to the historical perspectives of STI in Ethiopia. Section two explores the STI policy (2012) and strategies and the empirical data regarding the STI activities in the country. The third section includes discussions on the challenges of STI implementation and finally the fourth section is dedicated to the conclusions and recommendations part.

Historical Perspectives of STI in Ethiopia

Four years before most of the developing countries were introduced to science and technology policy by the United Nation in the Science and Technology conference 1979, the socialist Derg regime established Ethiopia Science and Technology Commission for the first time in December 1975 by proclamation No. 62/1975. It was set up with the mission to initiate, organize, direct and promote scientific and technology research and development endeavors. Nonetheless, the commission in its 16 years of existence during the regime has contributed little to improve the lives of the majority. In fact, the commission was expressly tasked to develop National Science and Technology Policy (STP) no sooner than in 1987. Yet, it was in the middle of the policy formulation process that the Derg regime was defeated by the Ethiopian People's Revolutionary Democratic Front (EPRDF) in 1991.

Soon after the regime change, the commission resumed the process and continued to develop the policy by taking into account the series of reforms including the new free market economic policy and issued the first National ST Policy of its kind in 1993. The Commission was then reestablished in 1994 by proclamation No. 91/1994 of the Transitional Government of Ethiopia. A year later, following the establishment of the Federal Democratic Republic of Ethiopia (FDRE), it was reinstituted as an Agency.

The government recognizing the ever increasing importance of science and technology on economic growth and development, it elevated the Agency to a full-fledged ministry, Ministry of Science and Technology (MoST). The Ministry was established under the auspices of the office of the Prime Minister and council of ministries by proclamation No. 604/2008. The office was then restructured in 2010 to fit in with the definitions of powers and duties of the executive organ of the FDRE by proclamation No. 691/2010. Subsequent to the introduction of the Growth and Transformation Plan (GTP), aligning the STI policy was a necessity, and it was revised in 2012 to accommodate the changes in strategy of the country.

National System of Innovation

Examining the Ethiopian STI policy involves a proper understanding of the various sub-systems that made up the national system of innovation. Although there is no universally agreed definition of system of innovation, Freeman's (1987) defined a system of innovation as "the network of institutions in the public and private sectors whose activities and interactions initiate, import, and diffuse new technologies". The approach that was pursued by Freeman (1988), Lundvall (1988, 1992) was used to address the framework of national system of innovation to serve the purpose of this paper. Accordingly, the national system of innovation encompass the often interrelated and interdependent components including firms, industries, higher education institutions (HEIs), research institutes, Technical and Vocational Educational Training Colleges (TVET), and other government entities that are essentially engaged in science and technology. As such, the Ethiopian STI policy (2012) acknowledges the above mentioned actors in the national system of innovation. Moreover, the document established linkages of the R&D activities by the actors in a way that enhance long-term competitiveness and growth of the country.

STI Institutional Governance Framework

Economics literature has the industrialized countries like the US, Japan, China, South Korea, Taiwan, India and others have made the most use of STI to transform their economies into advanced and emerging economies. According to Padilla and Gaudin (2013), governments play a crucial role in national systems of innovation by funding and participating in the knowledge production and dissemination through public universities, research center and the establishment and amendments of institutions such as laws, regulations and policies that support STI activities.

It is of paramount importance to first look into the evolution of the economic policies and strategies of the country to get a grip of the focus of STI policy and its implementation in the country.

Ethiopia for the first time in its modern history has made an attempt to consciously plan the course of its economic development during the Imperial Regime in 1957. The Imperial regime begun to assume considerable responsibilities to boost investment and the policies were designed to attract foreign investment. In a similar move, import substitution industrialization and the exportation of the primary products were central to the economic policy of the country. However, as the policy emphasized private-led import substitution industrialization, the low level of domestic entrepreneurship failed to bring about the desired development.

With the deposition of the monarchy by the Derg regime in 1974, sweeping socialist reforms characterized by an across-the-board act of land and private property nationalization and the expropriation of foreign capital that led to slow economic growth and stagnation. The end of the civil war in 1991 and the rise of the EPRDF (Current Governing Party) to power marked a new era of radical transformation in the economic domains of the country. The essence of the new economic policy became the transformation of the command economy inherited from the previous regime into a functioning market-based economy. Over the last two decades, the country has implemented various development strategies. The agricultural development strategy which was referred to as, 'The Agricultural Development Led Industrialization (ADLI)' was introduced in 1994/95. Since then, agriculture has been leading the economic growth which pushed for the reinforcement of agricultural research institutes in the country. According to National Bank of Ethiopia (2012/13), the agriculture sector represents 42.6 % of the GDP and over 80 % of the population earns their livelihood directly or indirectly from agricultural production. The fact that Ethiopia has abundant resources and labor, the focus given to the agriculture sector was well justified, and as a result the sector has now been the prime driver of the economy in the country.

Four years back, the Government of Ethiopia has started the implementation of a five-year development plan (2010/11-2014/15), famously known as the Growth and Transformation Plan (GTP). The plan is focused on achieving rapid and all-inclusive economic growth and development. Furthermore, it is aimed at achieving middle income status for the country in 2023. Besides, the plan is also geared towards effective and efficient attainment of the Millennium Development Goals which were set by the United Nations in 2000.

In response to the changes in the policy directions of the country, the STI policy was once again revised in a way that fits in with and supports the translation of the GTP into action. In other words, the STP policy was crafted in a way that addresses the areas of priority in the GTP. To put it another way, it was designed to contribute significantly in transforming the country's economy from agricultural-led to industrial-led.
Many of the development-related policy documents in Ethiopia imitate the path that the East Asian countries pursued to avoid the poverty trap. Export-based markets and the accumulation of technological capabilities were considered as the main drivers of East Asian countries' success in achieving economic and social development. South Korea and Taiwan are the two exemplary countries that most cited in this regard.

According Keun Lee (2012), Korea has been one of the most successful latecomer economies to have achieved rapid economic growth and approached the ranks of the advanced economies. Cited by the same author, a technology-based view in catching-up development, (such as OECD 1992; Hobday 1995; L. Kim 1997a; Dahlman, Westphal and Kim 1985), argues that Korea and other newly industrialized economies (NIEs) have tried to catch up by assimilating and adapting the more or less obsolete technology of the advanced countries (Vernon 1966; Utterback and Abernathy 1975; Kim 1980).
The STI Policy (2012) primarily sets the general directions and major implementation strategies identified upon series of consultative discussions held with stakeholders. It is thus presented and analyzed as follows:

The vision of the STI policy is put as follows:

"To see Ethiopia entrench the capabilities which enable rapid learning, adaptation and utilization of effective foreign technologies by the year 2022/23."

The mission of the policy:

"To create a technology transfer framework that enables the building of national capabilities in technological learning, adaptation and utilization through searching, selecting and importing effective foreign technologies in manufacturing and service providing enterprises."

The vision clearly envisages the establishment of national innovation systems that will search for, select, learn, adapt and utilize appropriate and effective foreign technologies. It is imperative to comprehend that the main thrust of the mission and vision statements is to ensure effective and efficient achievement of the national development agenda of the country.

Objectives of the New National STI Policy

The major objectives of the Ethiopian STI policy (2012) are to:

1. Establish and implement a coordinated and integrated general governance framework for building STI capacity;
2. Establish and implement an appropriate national Technology Capability Accumulation and Transfer (TeCAT) system;
3. Promote research that is geared towards technology learning and adaptation;
4. Develop, promote and commercialize useful indigenous knowledge and technologies;
5. Define the national science and technology landscape and strengthen linkages among the different actors in the national innovation system;
6. Ensure implementation of STI activities in coordination with other economic and social development programs and plans;
7. Create conducive environment to strengthen the role of the private sector in technology transfer activities sustainably.

The objectives are well0articulated and comprehensive. It addresses the most important aspects of science and technology.

Policy Directions and Strategies

The STI policy in force has identified eleven cornerstone policy issues. However, to serve the purpose of the paper, only six crucial elements of the policy are considered. These include technology transfer, research, human resource development, financing and incentive schemes, government-university-industry linkages, and international cooperation.

Technology Transfer

By exploring the important aspects of the policy, it can be said that poverty alleviation is at the heart of the STI policy document. The technology transfer component of the document, thus, primarily emphasizes on devising a system of learning, adapting, utilizing and disposing of imported foreign technologies that lifts millions out of abject poverty and transform the economy into one of the middle income economies. However, it lacks explicit statements explaining the social inclusive strategies that address the socio-economic issues affecting the local community. It is indeed obvious that social inclusiveness is an important aspect of development. Poverty reduction programs and technologies on how to tackle problems of food insecurity, housing, health, and unemployment are missing. A technology capacity building document which has been produced by the Ministry of Education (MoE) (2014) clearly stipulates and prescribes imitation of foreign technology as an ideal strategy to escape poverty trap. The document envisions that Ethiopia will come out of the poverty trap by 2020, and it is expected to join countries in the ranks of lower-middle income where the per capita income will reach a little over 750 dollars. Besides, the document predicts that the country will reach an average-middle income with the per capita income range of 5000 dollars during 2020-2038. During this period, mainly the improvements of the copied foreign technologies will derive economic growth. Over the years, the country will develop its innovative capacity and is therefore expected to conduct blue sky researches to develop new technologies that would expand the frontiers of knowledge. As a result, innovating new technologies is believed to ultimately take the country out of the middle income trap by 2038. By then, the per capita income is expected to reach 8400 dollars or more.

Grossly, the document describes the path that the country will follow as it alleviates poverty to join the developed economies.

However, except for mentioning the importation of the existing foreign technologies as key, the STI policy document fails to propose the sequence of the modes of learning. Keun (2012) pinpoints the sequence of the modes of learning as followed by most of the East Asian economies. The author detailed the modes of learning sequentially as follows and it begins with learning by working/doing, licensing, in-house R&D, overseas R&D, post or public-private consortium, international mergers and acquisitions, ends with horizontal collaboration or alliance based on complementary assets.

According to Global Competitiveness Report (GCR) (2013/14), the Ethiopia's capacity for innovation is rated very low, i.e., 2.6 on the 7.0 scale, while the mean value is 3.6. The country ranked 141 out of 148 countries. This might, in itself, indicate how much the country is lagging behind in the frontiers of new knowledge production. However, given the poor innovation capability the country crafted a strategy that emphasizes on enhancing the ability to learn and absorb foreign technology.

Research

Countries are striving hard to transform the structure of their economies to a knowledge driven economy. Indispensable at the helm of the knowledge economies is excellence in research that in turn produces a new knowledge that contributes to the betterment of the lives of people. Hence, the significance of research cannot be overstated as it is also indicated by Meek and Davis (2009), where Johnstone and Marcucci (2007) note: "Research capacity is important as well for low-and middle-income countries: for the sake of their economies, for the requirements of effective management and sound policy-making in their governments as well as in the entities of their civil societies, and for the preservation of their national histories, cultures, and identities."

Relevant adaptive, applied and basic researches are strategic importance to any country. There had already been recognition of the importance of research for the country's economic development. From the onset, the Transitional Government of Ethiopia promulgated the Ethiopian training and education policy in 1994 where it mentions as a strategy that, "research of practical societal impact will be given priority and the necessary steps will also be taken to facilitate the coordinated efforts of all those concerned."

As the research component of the policy is concerned, the types of research, priority setting and modes of evaluation are discussed here under.

As is the case in many developing countries, one can see that the trend of the research focus in Ethiopia is generally leaning towards the ones with applied outcomes. Policy documents including STI and Training and Education policy of the country confirm the same and have statements that explicitly made it clear a greater focus is given to applied researches.
Asked about why it is so, an interviewee from MoST had the following to say:

This is mainly because the government is the main funder of researches and it is obliged to make sure that tax-payer's money is channeled to address the societal issues at its best. He further elaborated that the inclination and focus towards these types of researches is that they have to contribute to the development agenda of the country. Apart from that he explained the shortage of qualified researchers and technicians and old research facilities and technologies are other constraints that emphasized on funding more of applied researches.

The same question was raised for the research officers in HEIs and the following is the extract from their interview responses:

Though universities have several different projects which are financed by different stakeholders, they all agreed that it is valid for research focus to be more on solving the socio-economic problems of the society. Even one has to ask this, 'what is the importance of doing research if it is not designed to improve the quality of life of people?' However, all the interviewees emphasized that a balance must be struck between applied and basic researches in the long term as the country's excellence in STI activities is heavily dependent on technological innovations.

The interview responses from all the interviewees reveal that the research focus is generally on exploitative researches. However, it is worth noting that explorative researches are not totally avoided as is evidenced from the policy and empirical data. Besides, the learning process creates a platform to develop capability that in effect could help the country to leapfrog to latest technologies in the years to come.

The Gross Expenditure on Research and Development by research type shows that 56% of the budget was spent on applied research and 33%on experimental and the remaining on basic research which is consistent with the priorities of the government(2014 MoST Critical Mass Training).

Priority setting is one of the key tasks in STI policy. According to Godinho and Carca (2009), priority setting in science and technology involves two major aspects: decisions about allocation of resources; and coordination of different actions and actors that are involved in the S&T policy. Also authors such as Dasgupta and David (1994), Chalmers et al (2014), European Science Foundation (2013), acknowledge the importance of explicit priority setting exercise and argue that priority setting provides the basis for shared vision and long term research agenda. Furthermore, it is imperative to note that priority setting is crucial in the sense that it necessitates proper identification and integration of stakeholders. In addition, it is vital in ensuring the optimal utilization of the scarce resources.

Priority setting is as significant to Ethiopia where STI activities are haphazardly coordinated the scant financial resources seriously constraining efforts in the area. The STI Policy (2010) identified areas of research and technology priorities to deal with the major socio-economic, political, legal and technological problems of the country. The document recognizes nine areas of research and technology priority programs that are enumerated as follows: (1) agricultural productivity improvement program, (2) Industrial Productivity and Quality Program, (3) Biotechnology; (4) Energy Technology; (5) Construction Technology; (6) Materials Technology; (7) Electronics and Micro-Electronics; (8) ICT and Telecommunications; (9) Water Technology.

In fact, the research priority areas were further refined and developed to be aligned with the seven pillar areas of the GTP (2010) of the country. All line ministries and agencies at federal and regional levels cascaded the national priorities to fit their respective missions. Down the line, research priorities have also been identified by higher education institutions and public research institutes. Similarly, respective institutes, colleges, and units of higher education institutions have developed thematic areas to do research and development to contribute to the national development goals of the country.

There are a number of methods for priority setting including science foresight, road mapping and expert panels. One among these, science foresight is gaining much wider acceptance for developing priorities at national and regional levels.

The European Scientific Foundation-ESF (2013) defines science foresight:

a systematic, participatory, prospective and policy-oriented, time-limited or permanent process aimed at actively engaging science stakeholders, e.g., researchers, funding organizations and the private sector, in the assessment of present science and the anticipation and recommendation of science futures based on inner scientific, technological, economic, environmental, political, social and ethical constraints.

According to ESF (2013), the objectives of using science foresight in priority setting are elaborated. The objectives of science foresight as included in the document are to:

- minimize inefficiencies through optimal utilization of funds,
- strategically search for and attract potential researchers,
- serve as a guide for long term capacity development,
- build new networks across fields,
- identify emerging patterns and new potential in disciplines, interdisciplinary fields, upcoming new topics, innovative research technologies or the availability of new facilities.

As already mentioned above, the objectives are relevant and worth considering in priority setting exercise. And the interviewees from MoST and the HEIs were asked if there are specific priority setting methods that they employ and if they recognize the benefits.

The typical interview response by the interviews is presented as follows:

Even though I can't tell which method specifically was employed, the process of priority setting at the national level was done in a very participatory way involving stakeholders from the various line ministries, higher education institution, and the private sector. The informant was not able to say about the benefits but fully understands that priority setting is quite essential. However, the interviewee was asked if there are permanent teams that are responsible for continuously scanning the environment to suggest on possible change of directions and priorities, the answer was no, explaining there is no permanent team constituting of all the stakeholder to handle on these matters.

The interview response from the research officers was no different to that of the informant from MoST.

Priority setting exercises are common and are done by reviewing various national strategies and policies documents. A specific method employed was not mentioned as science foresight. However, expert opinion was used in the HEIs in cascading priorities to fit to the national development agenda.

As far as practical issues are concerned, priority setting exercises are common in STI endeavors. Nevertheless, the methods that the exercises employed are not known to the informants. It is important to note that achieving excellence in research and technology requires employing scientific methods of establishing national and regional priorities.

In designing and implementing science, technology and innovation (STI) policy, another important aspect of research is the models of research evaluation. As cited in Hansen (2005), Stufflebeam (2000) defined the concept of evaluation as 'a study designed and conducted to assist some audience to assess an object's merit and worth'. In other words, putting appropriate research evaluation models in place ease the assessment of whether or not 'what and how research' performance conforms to expectations. By the same token, evaluation models provide the basis for evaluating research proposals.

Rip (2003) proposes that there are three kinds of evaluation: ex ante evaluation (of project proposals) and ex post evaluation (of finished projects and programs), and impact assessment (of socio-economic effects of a program or a project).

The MoST interviewee was asked if there are nationally established models of evaluation.

The interviewee started by recognizing the importance of having a standardized model of evaluation and he elaborated that the Ministry has developed a research award directive number 02/2013 that details the evaluation criteria for selecting research proposals for a grant.

And he was then asked if the stated evaluation criteria are used for all forms of research.

The interviewee confirmed that it is the standard document that is being used research proposals regardless of the purpose of the evaluation and in fact the nature of the problem to be evaluated.

However, the evaluation criteria developed by MoST does not take into account important factors including the nature of the problems, purpose, and duration.

Similar interview questions were raised to the HEI research officers and their reply is summarized as follows:

All the HEIs have guidelines that serve for evaluating research proposals developed at a university level. However, several issues have been raised as far as the appropriateness of the criteria is concerned. There have been series of complaints by staff of the universities about the allocation of points to the criteria. They went on explaining that people have been complaining about the criteria putting too much emphasis on the ranks of researchers instead of the merit of the proposals. One of the interviewee mentioned that his university has recently revised the guidelines by taking into account the issues. In all the universities, previous research project implementation, academic and research qualification and experiences, multidisciplinary nature of the proposed research proposal, technical and scientific merit of the proposal and major anticipated research output/s and its role in achieving the grand Growth and Transformation Plan and the Millennium Development Goals are used as criteria to award research grants.

Peer review has long been used for evaluating research proposals in higher education institutions. Langfeldt (2001) asserts that peer review is the foundation to assure quality of scholarly researches. However, the author in his study found out that there are large variations in what criteria reviewers emphasize and how they are emphasized. He reiterated that this may lead to various kinds of bias. In fact, as the criteria have no standard operationalization or interpretation, there are possibilities that reviewers promote personal favorites. For instance, Langfeldt (2001) found that rating scales and budget constraints on funding rather than guidelines have substantial effect on proposal selection process.

On similar grounds, Heinze (2008) asserts that funding structures with a strong peer-review component tend to overfund mainstream research that follows established research lines, particularly in traditional disciplines, the approach could already be biased towards exploitative research while discouraging explorative research. This problem is compounded by the relatively shallow knowledge of reviewers who may not be exposed to multidisciplinary and emerging fields.

Asked whether or not researchers have problems with peer review evaluation of proposals, the research officers in the universities have the following to say:

Year after year, as peer evaluation results arrive and are posted to notify researchers, complaints flood into the research council offices. The complaints has to do with individual subjectivity in rating and ranking, shallowness of the knowledge of panel of reviewers leading to the tendency of picking projects that they are most familiar with, etc.

The above interview response marks a good concern as it is consistent with the empirical findings of both Langfeldt (2001) and Heinze (2008). It is obvious that there is no easy answer as to how to tackle subjectivity in peer review. Hansen (2005) outlines two important criteria for evaluation model design that may be based (i) on the purpose of carrying out an evaluation (control or learning), and (ii) on the characteristics of the problem that the program or organization under evaluation aims to resolve.

As far as duration of projects is concerned, universities generally fund projects as small scale, medium scale or large scale. The duration for small scale researches is usually a year or less whereas for that of medium scale research the duration may extend to up to three years. Large scale researches may extend up to more than five years. According to Bourke and Butler (1999), the time regime underlying institutional funding 'may allow for the identification of research problems of wider and deeper content, closer to the "state of the art" work in the field'. In contrast, short-term funded grants 'may predispose researchers to choose lesser problems capable of more predictable and safe completion'. Again the short-term funding tends to encourage the exploitation mode which favors risk averse research strategies and leads to proximate and often predictable outcomes, while high impact research seems to be connected to the explorative mode conducted using long term funding. Thus, it is worth noting that project duration and fund has its implication on the research problems to be studied. There are no platforms to establish and develop modes of evaluations depending on the nature of researches. Additionally, there are no nationally developed guidelines that direct the evaluation of proposals. In fact, it is important to note here that the 'one size fits all' maxim does not work in designing the guidelines as well as the modes of evaluation.

Diana Hicks (2012) provided overview of a national approach to performance based schemes for funding university research. Herbst (2007) in explaining the rationale of performance-based funding puts it this way:

funds should flow to institutions where performance is manifest: 'performing' institutions should receive more income than lesser performing institutions, which would provide performers with a competitive edge and would stimulate less performing institutions to perform. Output should be rewarded, not input.

Hicks defines a performance based funding system as one that meets the following criteria:

- Research must be evaluated. Evaluations of the quality of degree programs and teaching are excluded.
- Research evaluation must be ex post. Evaluations of research proposals for project or program funding are ex ante evaluations and are excluded.
- Research output must be evaluated. Systems that allocate funding based only on PhD student numbers and external research funding are excluded.
- Government distribution of research funding must depend, or will soon depend, on the results of the evaluation. Ex post evaluations of university research performance used only to provide feedback to universities or to the government is excluded.
- It must be a national system. University evaluations of their own research standing, even if used to inform internal funding distribution are excluded.

Key findings of performance based research funding revealed a positive impact in promoting scientific publications, but resources committed may not necessarily warrant that results would be off value to the general public. Moreover, Hicks argues that performance-based research funding systems may compromise other important values such as equity and diversity besides to its time consuming and expensive nature.

Despite the increasing trend in the number of publications as is shown in figure 2, the quality of scientific research institutions in the country, according to Global Competitiveness Report (GCR) (2013/14), is rated 3.1 on 7.0 scales while the mean value is 3.8. Against this background, the same report ranked the country 61 out of 148 countries for the procurement of advanced technological products by the government which is rated 3.6 on the scale of 7.0 where the average is 3.5. Cognizant of the fact that most of the HEIs are at their infancy, the government's commitment to equip laboratories and research institutes with state-of-art technologies and facilities is something that should be applauded.

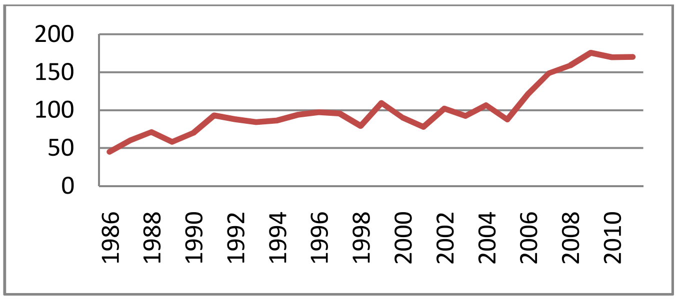

Fig. 1. Scientific and Technical Journal Articles

Sources: (World Bank, 2013)

Figure 1 above shows that number of scientific publications is growing over the years and the trend clearly shows that it is on the rise. The growth could be attributed to the government's huge investments on higher education institutions and research institutes.

Human Resource Development

The policy document acknowledges in clear terms that there is shortage of qualified and competent manpower to search for, select, learn, adapt and disseminate existing foreign technologies. Furthermore, the STI policy and other policies like training and education policies recognize human resource development as the key for development and the country sees the people as the most important resources to start with in all its development activities.

However, GCR (2013/14) indicate the limited availability of scientists and engineers as attributing to the lower rating of 3.0 on the 7.0 scale (while the average of the score is 4). Moreover, the availability of research and training services is rated 3.2 on the 7.0 scale. Equally important to the expansion of HEIs is ensuring that adequate numbers of academic and support staff who are trained to handle jobs created, however, the extent of staff training is rated 3.3 on the 7.0 scale.

Similar to the case of South Korea in the 1960s, the human base in Ethiopia though growing steadily is poor. According to GCR (2013/14), the gross enrollment rate at tertiary education institutions in Ethiopia is low at 7.6%. And the country is ranked 124 out of 148 countries. Despite of the figures, Ethiopia has achieved impressive results in the sector. As is indicated in the graph below, the enrollment rate grew exponentially.

The Ministry of Education's Book of Abstract (2012/13) shows that the number of students enrolled in undergraduate programs and postgraduate programs in 2008/09 was 310,702 and 10125 and the numbers grew to 555848 and 31304 in 2012/13.

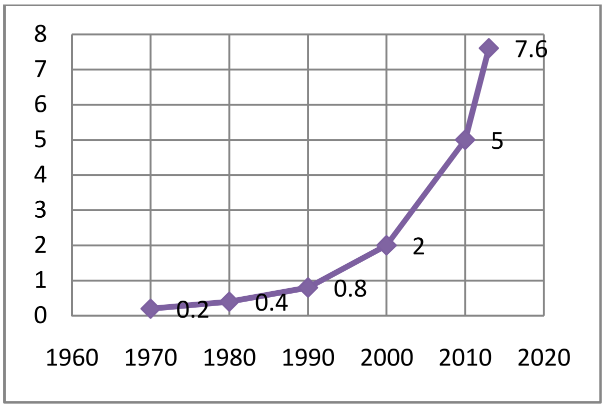

Fig. 2. Higher Education Gross Enrollment Rate

Source: (Governance Reforms in Higher Education, UNESCO 2013)

Figure 2 indicates the exponential changes in the growth rate of enrollment in higher education and data of the number of enrolled students is impressive.

The shortage of technical and research personnel coupled with shortage of financial resources are some of the reasons that called for aggressive importation of foreign technology as an ideal catch-up strategy.

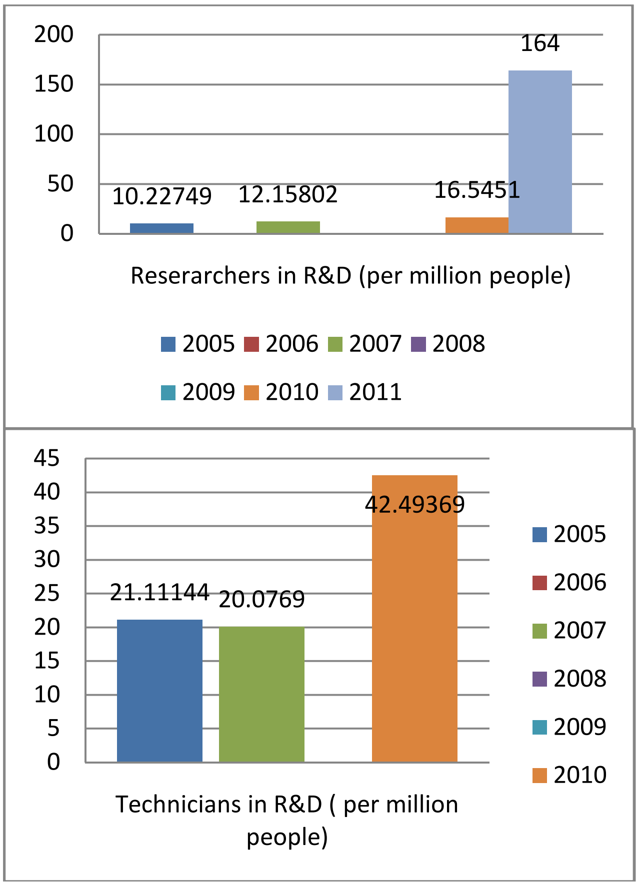

Fig. 3. Numbers of Researchers and Technicians in R&D

Sources: (World Bank, 2013)

The STI policy heavily relies on HEIs and TVETs for human resources development and research and development and technology transfer. These institutions are considered as pillars in nurturing and building broad based competences on STI. Thus, the Ethiopian government has been making huge investments in the expansion of higher education institutions. According to (NBE, 2012/13), over the past two decades, the number of public universities in the country has increased from 2 to 32. Besides, according to the same report, the number of private tertiary level of institutions has reached 67 from 34 in 2006/07.

Apart from the university goers, those who failed to meet the entrance requirements are placed in TVET Colleges which are entrusted with the mission of producing middle level technicians capable of transferring foreign technology. In this regard, the government has been fully committed to bridge the gap by producing innovative youth through education and training. The crafted strategies are well conceived yet what is missing is that they do not include mechanisms as to how stakeholders including universities can motivate the youth and make careers in science, research, technology, and innovation as attractive as is possible.

As it is indicated in the chart below, 98% of R&D personnel in the country are employed in higher education and government R&D.

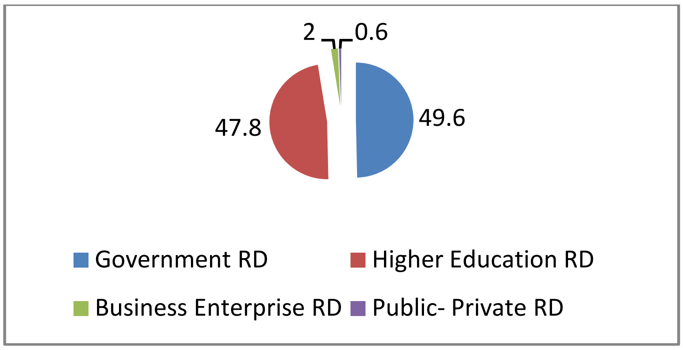

Fig. 4. R&D Personnel by Sector

Sources: (2014 MoST Critical Mass Training)

Data on researchers by background shows,31% of researchers in the country are Agriculture professionals, 19% are Medical and Health researchers, 17% are researchers from Social Sciences, 15% are researchers from Natural Sciences, 9% are Technology and Engineering, 7% are Humanities and others accounts for 2% (2014 MoST Critical Mass Training). These figures are not of any surprise to the author for the country had been totally focused in enhancing its agrarian economy for some time now.

Keun (2012) argued capability and technological development as the most important elements of South Korea's success. Without a strengthened R&D capability, sustaining economic growth is not possible. Cognizant of this fact, the recent policy shift towards training 70% of students in HEIs in the areas of science and technology seems to be well justified. This, therefore, would hopefully fill the gap of technology and science researchers in the decades to come.

As far as human resource of the HEIs is concerned, the interview responses are extracted as follows:

The universities included in the study have planned and organized various short term, medium term and long term trainings for their staff. Universities have trained staff related to research, including basics of research proposals writing, Econometric models, guiding the use of Statistical Package for Social Sciences, Stata, Geographic Information Systems, and writing articles for publication to mention a few. One of the universities has also introduced an initiative where the younger staff will have to team up with seniors for research grants. Besides, they mentioned that reward mechanisms are also geared to reflect research performance, including promotion and the use of accelerated promotion schemes, marking publications to count for proposal evaluations, supporting travel and conference attendance, permitting leave for staff on data collection are some of the ways that are used to boost research undertaking of their staff.

Financing and Incentive Schemes

The Gross Domestic Expenditure on R&D as share of GDP has reached 0.63 % in 2013 from 0.24 % in 2010 (MoST Critical Mass Training, 2014). About 97% of the source of fund for the R&D comes from the state and revenues generated by its institutions. The contribution of the private sector on R&D is meager. In fact, similar report shows that R&D spending of the private sector is disproportionately low, only 0.1 % of its total expenditure. According to GCR (2012/13), the country's company spending on R&D is rated 2.2 on the scale of 7.0 (where the mean is 3.3). These figures show the poor engagement of the private sector on R&D.

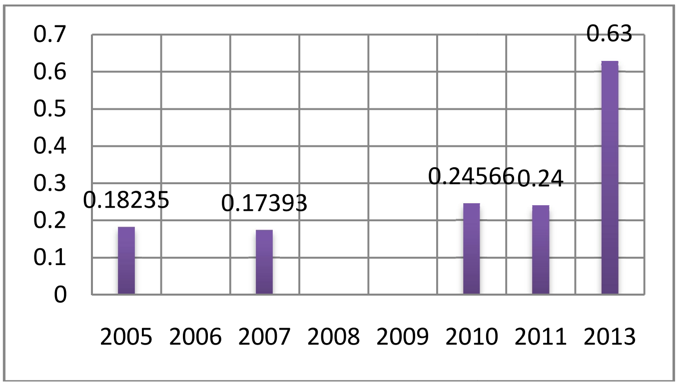

Fig. 5. GERD/GDP on R&D Per cent

Sources: (Compiled from 2014 MoST Critical Mass Training and World Bank)

From the figures above, it is visible that the government is the major funder of R&D and technology transfer projects. Dasgupta and David (1994) argue that economists take the view that the argument for public funding of science can be justified for the following reasons:

- The fact that the economic value of science is difficult to forecast or even to assess after the fact.
- The benefits that may accrue from science are uncertain, e.g. a small investment may yield large and highly dispersed benefits as in cases where fundamental advances in knowledge serve as inputs for applied research and development efforts that in turn yield a wide range of products and services.
- The market failure argument postulates that the uncertainty associated with results from science and the distribution of these benefits across society may lead to a systematic underinvestment in basic science if this task is left entirely up to the market.

Hence, it is natural that the government takes the lead in addressing inefficiencies in knowledge production. As a result the STI policy puts in place the three schemes to fill in the constraints of resources through direct engagements in knowledge production, the provision of intellectual property rights to inventors, and the provision of subsidized financing.

As cited in Keun Lee (2012), Kim (1997) in elaborating the path taken by South Korea, it is mentioned that the government went extra miles to motivate technology imports which were initially low. Later the government prioritized technologies that promoted exports, the production of intermediate capital goods and the likes. It is thus normal to see the dominant role of the government in financing STI endeavors and motivate the private sector to engage in the same.

Universities-Industry-Government Linkage

Collaborations and partnerships among the various actors in the national system of innovation are vital if STI activities are to bring about meaningful impact in the lives of people. As such, the STI policy document of the country properly addressed the various stakeholders of the national system of innovation. The list includes government, universities, research institutes, TVET institutions and industry as core actors in the system. The University-industry collaboration in R&D was rated 3.5 on the 7.0 on GCR (2013/14). The 'Triple Helix' is a terminology coined for describing a specific type of public-private partnership. In this context, university– industry– government relations have been depicted as a Triple Helix in evolving networks of communication (Etzkowitz and Leydesdorff, 1997). In Triple Helix theory, academic, industry and government are said to have equal roles to play in stimulating innovation in knowledge based society. As per the triple helix framework the following are considered as essentials: (1) universities stop pursuing knowledge for its own sake and re-direct towards issues of socio-economic matters and move to innovative applied research, (2) government focus on creating enabling environment with regards to regulations, tax incentives and provision of capital, and (3) the industry prepares itself to exploit research outputs. Triple Helix sheds light on alliances that are so far the most common form for commercializing research. The strength as well as effectiveness of the established linkages among these institutions largely depends on their tendency and capability to be involved in activities dealing with technology transfer.

The MoE has taken measures to foster and strengthen university-industry linkage by establishing offices in the public universities to leverage funding, sharing resources and expertise, and above all to serve as a bridge in commercialization of creative ideas.

The interview response from MoST and HEIs can be summed up as follows:

Universities are expected to be the pillars of the economy not only through training and educating people but also through other means that enhance the role of academia in a society such as by establishing industrial internship, incubation centers, and science parks, university affiliated enterprises, patent licensing, consultancy and soon. All universities in Ethiopia have established Knowledge and Technology Transfer (KTT) offices to disseminate research outputs that had in the past were left 'on the shelf'. It is evident from the Memorandum of Understanding that institutions and industry actors sign and commit to collaborations and partnerships. This has been increasing over time; however, the concern is on agreements that are on paper only. Though things are improving these days, it can be said that a lot remains to be done in terms of commercializing of research findings. Besides, the industries and the MSEs in the country are not ready to take on and exploit research and technology outputs from the Universities.

Thus, it is safe to say that university-industry linkage is not as well developed as it should have been in Ethiopia. The reports and interview responses indicate that link is weak.

International Cooperation

International cooperation in the areas of STI has been top on the agenda these days. The STI policy recognizes the essence of international cooperation and puts the role that it plays in terms of capacity building through manpower training, expert assistance, scientific visits, and collaborative researches, joint venture in technology transfer and funding of knowledge production and dissemination. Boekholt *et al.* (2009) grouped the drivers of STI collaboration under two categories namely, the 'Narrow Paradigm': drivers for international STI collaboration in STI policy; and the 'Broad Paradigm': Drivers from policy areas outside the STI domain. As already described, the narrow paradigm focus on international science and research collaboration linked to drivers 'intrinsic' to the science dynamics. According to the same author, the key drivers in the STI Policy are: excellence in research community; solving of specific scientific problems that requires international teams; the need to pool resources together; better access to scarce human resources for research; increase of (international) productivity and visibility of research; contribution to building institutional capacity in research organizations.

In line with this, Jacob and Meek (2013) argue that one of the ways in which countries are responding to globalization pressures is by promoting policies for higher education and research that emphasize mobility of scientific labor. They argue that the mobility of scientific labor is an indispensable prerequisite for capacity building and building world-class excellence. However, they stressed that mobility is still a mixed blessing since scientific labor like other scarce resources has a tendency to cluster towards the center. Hence, international mobility may have a negative impact in the short term for the less developed countries; however, the benefits may accrue in the long term.

MoST interviewee responded to collaboration and internationalization efforts as follows:

Lack of focus in sourcing science and technology information, and exchange of scientists and engineers were mentioned as problems by the informants. Strategic partnerships and alliances with other nations through both bilateral and multilateral cooperation in science, technology, and innovation should be top on the agenda. Like economic diplomacy, science and technology diplomacy should be reinforced and deployed.

The STI Policy sets the strategy for internationalization and collaborations of the higher learning institutions. However, as Boekholt *et al.* (2009), state good indicators need a strategic and clear policy cycle framework. Furthermore, since internationalization is characterized by mobility and sharing of resources there are concerns about who are better positioned to benefits and who are likely to be worse off from such collaborations. This is linked to 'brain gain, brain drain and brain circulation' occurring concurrently as examined by Heitor *et al.* (2014). This again centralizes the importance of developing indicators for international cooperation that are accepted by all stakeholders involved in a particular partnership or collaboration.

Challenges of STI Policy Implementation in Ethiopia

The major challenges of the STI from the interviews are summarized here under. Most of the issues are common to and shared by most developing countries as described by Padilla and Gaudin (2014). There is a common saying that 'a policy is as good as its implementation'. One of the most important challenges is found to be failure to effectively translate the policy into practice. This is mainly because of the following reasons:

Most policies that come from the top down to the bottom have implementation issues. The 'Top-Down' approach to policy formulation coupled with limited public awareness of the significances of STI has curtailed efforts in effectively implementing the policy. Similarly, the absence of programs that translate STI policy objectives into action contributes to the inefficiencies in the implementation processes.

The other important challenge is the shortage of qualified personnel in the national system of innovation in general and the various STI actors in particular. The lack of knowledge, skills and attitude of personnel at all levels of the system has constrained people from discharging their responsibilities in science and technology effectively.

The STI policy shows the direction and the commitment to facilitate linkages between the various players but in practice there is a manifestation of disconnect. There is immature coordination and collaboration of the STI stakeholders which was meant to bring about synergy. Specifically, the feeble link in the Triple Helix though improving overtime remains a big challenge in this regard.

The limited understanding of the benefits of STI by the infant manufacturing sector and the MSEs which lacks significant growth have hindered their active involvement in the system.
The lack of financial resources is the most significant barrier for STI development in developing countries, and Ethiopia is not an exception. The over reliance on state funding and the poor engagement of the private sector have also greatly challenged STI activities. In fact, the absence of different nationally developed guidelines and research evaluation models for the allocation of the scant fund is a barrier that adds up to inefficiencies and resource wastages.

The lack of data warehouses, and poorly designed websites with little or no information about the stakeholders makes it hard to grasp developments in the sector. STI infrastructure is crucial for searching for, selecting, learning, adapting, and disseminating technology. However, outdated laboratory facilities, insufficient equipment and above all the poor telecommunication networks in Ethiopia contribute to the poor performance.

The poor institutional culture to monitor and evaluate programs and policies implementations has also its implications in the overall effectiveness of the accomplishment of the mission of the STI policy.

Conclusion and Recommendation

This part of the paper presents the conclusion and recommendation. The conclusions of some of the main findings are discussed here.

Conclusions

In this paper, the author focused on assessing some of the important aspects of the STI policy and its implementation challenges. In conclusion the following points are made:

The evolution of the STI policies overtime and the recent increments on STI funds are indications that there is unwavering commitment from the part of government to support science, technology and innovation activities. As a result, the achievements in areas of research, technology transfer and most importantly human resources development are impressive. However, it is important to note that a lot remains to be done in terms of refining and developing national programs and directives that would serve as a comprehensive guideline for the smooth functioning of the robust national system of innovation. The STI policy objectives were examined carefully and they are crucial to effective and efficient attainments of the vision of the country. It can be said that the policy has addressed the most important elements and are sound. Concerning technology transfer, the document does not explicitly state the social inclusiveness strategies essential for addressing the societal problems. In terms of research, the document fails to categorically specify the amount of resource that has to be allocated for applied and basic research. It is visible that the focus is on applied research and In fact, learning and adapting to keep pace with the frontiers as a way to catch-up is the order of the day. Yet, what makes catching up difficult is that there always are new sectors coming up with many new frontiers emerging. Hence, determining the mix of the types of researches is crucial. As far as priority setting is concerned one can see that adequate attention is not given same as the establishment of research evaluation models to fit into the various kinds of disciplines.
Pertaining to the human resource development component, it can be said that it is well designed except for failing to include the mechanisms on how to attract the young to pursue science and technology. As far as research and technology financing is concerned, the government will remain to be the major funder. However, engaging the private sector to a greater extent is critical. In terms of linkages, the triple helix is only taking roots these days and one can see that all the stakeholders does not have the feel of the mutual benefits of the innovative endeavors to contribute their fair share in the system. International cooperation is matter of indispensable but programs are not designed to handle matters of international cooperation. Generally, the policy document categorically emphasizes on capacity building which is the most fundamental factor to a sustained development in STI.

Recommendations

Based on the above discussions and conclusions, the following suggestions are made:

Human capital development is the most crucial mover in the process of development. Therefore, the country should further strengthen its efforts in producing the right kind and number of STI manpower leaders, researchers, engineers, technicians, and support staff to ensure that positions are filled with appropriate incumbents. The country can also bridge the gap by engaging its diaspora who would build up critical levels of human capital bases in the sector.

The volume of financial resources earmarked by the government to support STI activities has been steadily increasing. However, the amount still remains scant. The following measures could be worth considering as a result: (1) the government should channel the scarce resources to focus on strategic STI areas; (2) the government should develop various funding instruments and modalities to allocate annual budget specifically devoted to science, innovation and technology. The government can introduce new methods of financing such as customized performance-based research funding systems (PRFS) to fit into the existing situation of the country; (3) universities may also use their internal revenues, and aggressively look for endowment funds from the private sector, non-profit organizations to fund R&D activities. Universities should also go extra miles to convince the private sector of the mutual benefits of R&D and technology transfer. Besides, provision of incentives to those private sector actors who are engaged in R&D through tax reliefs, allowing duty free importation of R&D facilities could further bolster their commitment to the system.

The establishment of functioning consortium of universities, public research institutes, industries, and the government should be a priority. The HEIs should play an insurmountable and a leading role in paving the strategy for the ‘Triple Helix’ to guarantee the most value for all stakeholders that in a way would bring about development in the country. Besides, universities should not only strengthen the ties with the already established MSEs but also design programs to develop youth entrepreneurship that in a way would counter challenges youth unemployment.

Similarly, harmonization among ministries and the alignment of priorities deserve the attention of politicians and office holders. A good starting point could be creating a strong partnership between MoST and MoE in terms of identifying priorities, developing fund allocation schemes, research evaluation models and international cooperation programs for a greater national significance. Strengthening and taking the coordination of federal and regional governments’ STI offices to the next level is also vital.

The expansion and upgrading of STI infrastructure of HEIs, public research institutes, laboratories could also improve R&D outcomes to the greater public.

REFERENCES

2014 MoST Critical Mass Training: International Workshop on STI Policy For National Development in Ethiopia, Bahir Dar, Ethiopia.

Boekholt, P. *et al*. 2009. Drivers of International collaboration in research, Technopol is group report, Manchester University.

Bourke, P., Butler, L., 1999. The efficacy of different modes of funding research: perspectives from Australian data on the biological sciences. Research Policy 28, 489–499.

Chalmers, I. *et al.* 2014. How to increase value and reduce waste when research priorities are set, Lancet 383:156-165.

David P. and Dasgupta P. 1994. Towards a new economics of science, Research Policy23 pp. 487-521.

Etzkowitz, H., and Leydesdorff, L., eds 1997. Universities and the Global Knowledge Economy: A Triple Helix of University–Industry–Government Relations, Cassell Academic, London.

European Science Foundation 2013. Science Foresight to Advance European Research, ESF, Strasbourg, France Chs. 1-4. 156–65.

FDRE Ministry of Science and Technology, Research Award Revised Directive No 2/2013

FDRE, Ministry of Education (2012/13), Educational Statistics Annual Abstracts, EMIS, Planning, Resources Mobilization Directorate, Addis Ababa, Ethiopia.

Federal Democratic Republic of Ethiopia Science, Technology and Innovation Policy, February 2012, Addis Ababa.

Federal Democratic Republic of Ethiopia. Ministry of Education. Path to Ethiopian Renaissance (Slide 2014).

Federal Democratic Republic of Ethiopia. Ministry of Finance and Economic Development. G*rowth and Transformation Plan*, 2010. Addis Ababa, Ethiopia.

Foss Hansen, H. 2005. Choosing evaluation Models: A discussion on evaluation design. Evaluation. 11, 447-462.

Freeman, C. 1987. *Technology Policy and Economic Performance: Lessons from Japan*, London, Pinter.

Freeman, C., 1988. Japan: a new national system of innovation. In: Dosi, *et al.* (Eds.), Technical Change and Economic Theory. Francis Pinter, London, pp. 330–348.

Heinze, T. 2008. How to sponsor ground breaking research: a comparison of fundingschemes, Science and Public Policy 35 pp. 202-218

Hicks, Diana 2012. Performance-based university research funding systems, ResearchPolicy 41 pp. 251-261.

Jacob, M. and L. Meek 2013. “Scientific mobility and international research networks: trends and policy tools for promoting research excellence and capacity building”, *Studies in Higher Education*, 38(3), pp. 331-344.

Keun Lee 2012. Differentiating the Korean model and the Lessons, A “Capability-based View” on Korea.

Klaus Schwab (2013/14). The Global Competitiveness Report. World Economic Forum.

Langfeldt, L 2001. The decision-making constraints and processes of grant peer review, and their effects on the review outcome. *Social Studies of Science*, 31(6), 820–841.

Leydesdorff, L. 2000. ‘The Triple Helix: an evolutionary model of innovations’, Research Policy, Vol 29, pp 243–255.

Lundvall, B.-Å., 1988. Innovation as an interactive process: from user–supplier interaction to the national system of innovation, In: Dosi, et al. (Eds.), Technical Change and Economic Theory. Francis Pinter, London, pp. 349–369. Lundvall, B.-Å.(Ed.), 1992. National Systems of Innovation:

Meek, V.L. and Davies, D. 2009. Policy Dynamics in Higher Education and Research: Concepts and Observations. In

Meek, V.L., Teichler, U. and Kearney, M., *Higher Education, Research, and Innovation: Changing Dynamics.* UNESCO/INCHER-Kassel, 41 – 84.

Padilla-Pérez, R. and Gaudin, Y. 2013. Science, technology and innovation policies in small and developing economies: The case of Central America, Research Policy, 43.pp. 749-759.

Rip, Arie 2003. Societal Challenges for R&D evaluation. In Learning from Science and Technology Policy Evaluation. Edward Elgar Publishing Ltd., Cheltenham, UK, pp. 32-53

TGE, Transitional Government of Ethiopia 1994. *Education and Training Policy*. EEP 86, Addis Ababa April 1994, 27 pp.

Towards a Theory of Innovation and Interactive Learning. Pinter Publishers, London.

UNESCO 2013. Global Education Digest. Comparing Education Statistics Across the World. Institute for Statistics.

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