## OCCASION

This publication has been made available to the public on the occasion of the 50th anniversary of the United Nations Industrial Development Organisation.

## DISCLAIMER



## FAIR USE POLICY

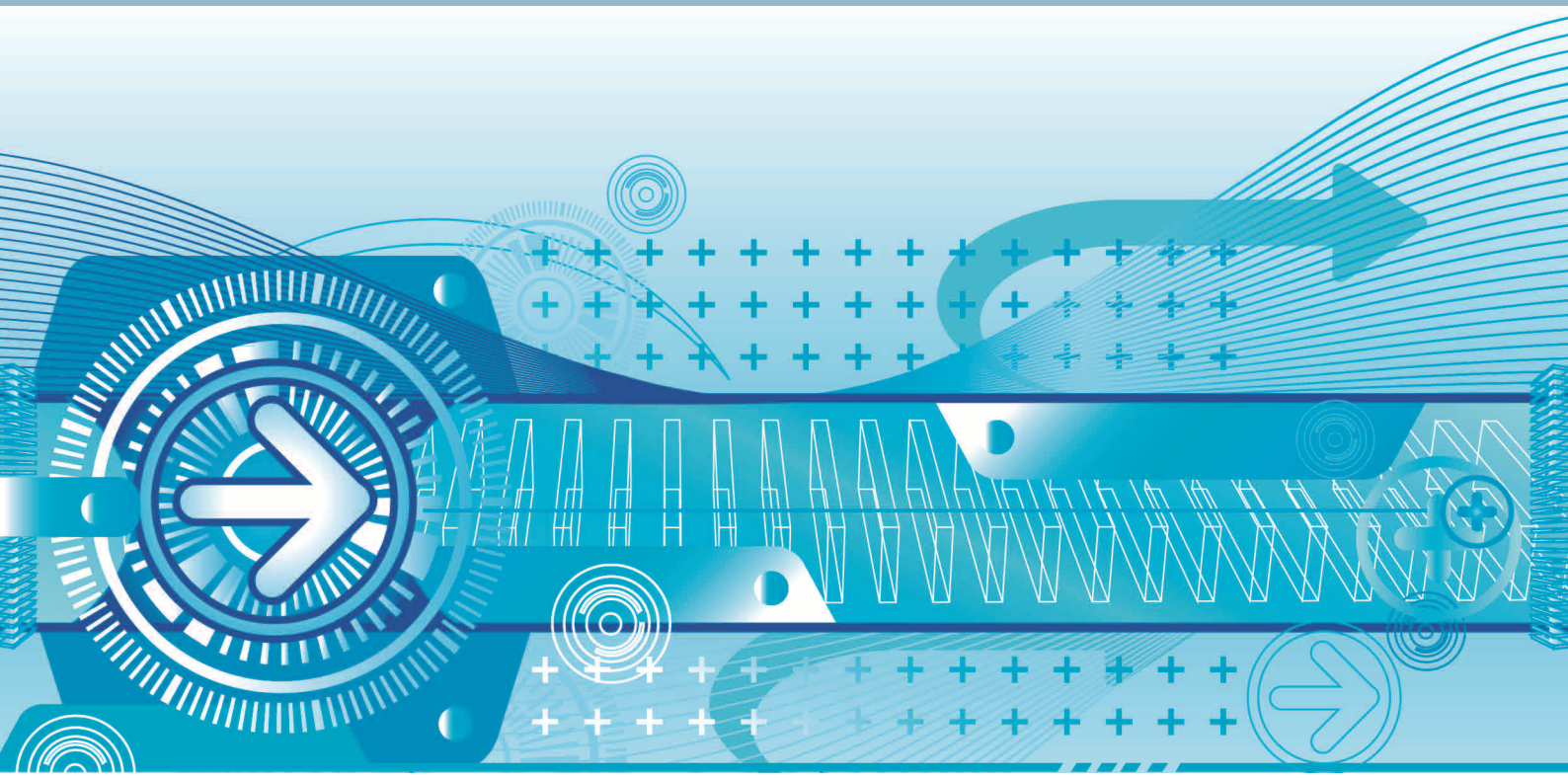


## CONTACT

Please contact publications@unido.org for further information concerning UNIDO publications.

For more information about UNIDO, please visit us at www.unido.org

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
Tel: (+43-1) 26026-0 · www.unido.org · unido@unido.org



# EVIDENCE-BASED POLICY MAKING

# THE GHANA NATIONAL SYSTEM OF INNOVATION – MEASUREMENT, ANALYSIS & POLICY RECOMMENDATIONS

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION

## Disclaimer:

# EVIDENCE-BASED POLICY MAKING

# THE GHANA NATIONAL SYSTEM OF INNOVATION – MEASUREMENT, ANALYSIS & POLICY RECOMMENDATIONS

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION

**December 2012**

# Contents

# 1.0 Key Acronyms and Abbreviations

| | |
|---|---|
| **ALL** | All Actors |
| **ARB** | Arbitrageurs |
| **BEs** | Business Enterprises |
| **BTS** | Bartlett's Test of Sphericity |
| **CAD/CAM** | Computer-Aided Design/Computer-Aided Manufacturing |
| **CAS** | Complex Adaptive Systems |
| **CEO** | Chief Executive Officer |
| **CEEII** | Centre for Entrepreneurship, Employment and Innovation Initiative |
| **CTVE** | Total Cumulative Variance Explained |
| **DASI** | Data Acquisition Survey Instrument |
| **DISK** | Data Information Statistics Knowledge |
| **DRUID** | Danish Research Unit for Industrial Dynamics |
| **EMEs** | Emerging Market Economies |
| **ESP** | Education Strategic Plan |
| **ESTAC** | Education Sector Technical Advisory Committee |
| **FDI** | Foreign Direct Investment |
| **FI** | Financial Institutions |
| **GCI** | Global Competitiveness Index |
| **GNSI** | Ghana National System of Innovation |
| **GNSIPU** | GNSI Policy Unit |
| **GoG** | Government of Ghana |
| **GOV** | Government |
| **GPRS** | Ghana Poverty Reduction Strategy |
| **GSGDA** | Ghana Shared Growth and Development Agenda |
| **HE** | Higher Education |
| **HIPC** | Heavily Indebted Poor Countries |
| **ICT** | Information and Communication Technology |
| **ICT4AD** | Information Communication Technology for Accelerated Development |
| **IDA** | International Development Association |
| **IIF** | Institute of International Finance |
| **IPRs** | Intellectual Property Rights |
| **ISSP** | Industrial Sector Support Programme |
| **ISTC** | Institutions Supporting Technical Change |
| **KBI** | Knowledge-Based Institutions |
| **KBISI** | (Department of) KBI Skills and Innovation |
| **KMO** | Kaiser-Meyer-Olkin measure |
| **MASTESS** | Mathematics, Science and Technical Education |
| **MDGs** | Millennium Development Goals |
| **MEST** | Ministry of Environment, Science and Technology |
| **MHTI** | Medium- and High-Tech Industry |
| **MoTI** | Ministry of Trade and Industry |
| **MTNDPF** | Medium Term National Development Policy Framework |
| **NSI** | National System of Innovation |
| **OECD** | Organisation for Economic Cooperation and Development |
| **PPP** | Public-Private Partnership |
| **R&D** | Research and Development |
| **RI** | Research Institutions |
| **SETIRC** | Science, Engineering, Technology and Innovation Research Council |
| **SME** | Small and Medium Enterprises |
| **STEMIT** | Science, Technology, Engineering, Mathematics and Information Technology |
| **STEPRI** | Science and Technology Policy Research Institute |
| **STI** | Science, Technology and Innovation |
| **STIDEP** | Science Technology Innovation Development Programme |
| **STIP** | Science, Technology and Innovation Policy Document |
| **TCF** | Technology Commercialisation Fund |
| **TVE** | Total Variance Explained |
| **TVET** | Technical Vocational Education Training |
| **UNCTAD** | United Nations Conference on Trade and Development |
| **UNIDO** | United Nations Industrial Development Organization |

# 2.0 Preface

**by Kandeh K. Yumkella**

Director-General
United Nations Industrial Development Organization

In order to accelerate sustainable and inclusive development in Ghana, there is a pressing need to encourage new industrial development approaches based on exploiting innovation, knowledge production and technology transfer mechanisms. These policy approaches represent ultimately the crucial determinants of any economy's ability to enhance its competitiveness and economic growth. Knowledge, organised systemically, not only refers to understanding that can be transferred extrinsically by learning, technology, hard copy and skills, but also to the tacit understanding held intrinsically in individuals, epistemic communities of practice and collective experience.

A National System of Innovation (NSI) represents the strength and quality of the systematically organised interactions and linkages between Government, Knowledge-Based Institutions (KBIs), Industry and Financial Arbitrageurs. Its main characteristics, as well as policies that shape them, are the critical determinants of efficiency and effectiveness in the creation and dissemination of knowledge, both tacit and codified, and the application of science, technology and innovation in the economy.

UNIDO acknowledges the importance of evidence for the Government of the Republic of Ghana (GoG) in deploying optimally policy instruments and targeting available resources (economic incentives and institutions) to achieve competitive advantage. This is attained through the development of a well-functioning NSI, working as a driver for long-term, socio-economic development.

The mandate of UNIDO – as one of the Specialised Agencies of the United Nations system – to provide its Member States policy advisory services is manifest in this Report.

This Report, The Ghana National System of Innovation – Measurement, Analysis and Policy Recommendations, maps and measures, as well as analyses the challenges, potential and opportunities arising from the NSI within Ghana's socio-economic context. The Report is a source of policy insight for supporting the GoG to elaborate a coherent, evidence-based industrial policy that articulates the role of science, technology and innovation throughout the economy.

The chapters in this Report are the result of UNIDO's services in policy analysis and empirical research on the Ghana National System of Innovation (GNSI). It aims to enhance the understanding of the role of the main Actors, their interactions and perspectives. This provides a strong basis for strategic plans, policies and management of policy actions to achieve effectively the national goals of sustainable competitiveness and growth to higher middle-income status.

# 3.0 Foreword

**by Hanna S. Tetteh**

Hon. Minister of Trade and Industry
Republic of Ghana

The objective to propel Ghana to high middle-income status has been addressed in several GoG policy initiatives and, within these frameworks, industrial development and industrial policy have become more prominent than ever before.

The Government's intent is to transform Ghana's "factor driven" economic model into an "innovation driven" industrial development model. The policy orientation is to deliver high levels of productivity through enhancing competitiveness, employment and equitable social and economic development. In order to drive industrial transformation, Ghana will require continuously enhanced modern skills and competences, and greater use of Science, Technology and Innovation (STI). The development of an effective and efficient NSI is vital in achieving this end.

This Report, The Ghana National System of Innovation – Measurement, Analysis and Policy Recommendations, provides an analytical view of the relevant Actors within the NSI, their inter-relational dynamics, and their individual dispositions with respect to barriers to innovation and innovativeness, and policy instruments.

The analysis is based on the GNSI survey conducted by the UNIDO in 2011. The value of this Report lies firstly in its display of the map and measure, in terms of the strengths and weaknesses, of organisational linkages in the GNSI. Secondly, it provides comprehensive policy recommendations. Thirdly, the UNIDO methodology serves as a high-resolution instrument to monitor, assess and evaluate policy implementation with respect to the GNSI. Fourthly, it facilitates the hard choices regarding policy decisions and trade-offs related to the role of STI in industrial policy. Fifthly, it permits a view of the direction innovation policy would need to take in order to complement Ghana's industrial policy.

In the context of Ghana's recent economic growth performance in attaining middle-income status, the survey results are encouraging due to the positive contribution of the Actors themselves and the findings and issues that emerge for policy considerations. Indeed, the main findings of the analysis indicate the following with respect to the GNSI:

- The crucial aggregate role of Government, Industry, Knowledge-Based Institutions and Knowledge Brokers

is seriously moderated by the relatively low-intensity linkages between Actors, and between Actors and the production system.

- Relatively low levels of innovativeness of Business Enterprises due to perforated, truncated or non-existent linkages between Actors.
- Asymmetric distribution, density and direction of Actor linkages leading to imbalances in the GNSI.
- Relatively high barriers to innovation and innovativeness in the areas of organisational capital, market demand, organisational constraints, and fiscal and monetary operations.
- Relatively low efficacy of policy instruments in addressing barriers to innovation.

According to the findings articulated in statistically significant terms, the GNSI should be a critical part of the overall framework for the GoG for the development of policies that enhance the central role of STI. At this stage of development, Industry needs support that can be effectively delivered through a comprehensive strategy which requires all key Actors' interventions, namely: Research and Development (R&D) in STI promoted by Knowledge-Based Institutions, state incentives and infrastructure improvements provided by the Government, as well as financial intermediation by Arbitrageurs, and industry's efforts to enhance its innovation profile.

As the GNSI survey results suggest, the GoG has several possible strategies for encouraging adaptive and innovative performance to strengthen the linkages among the key Actors in the STI system. This aim resonates with the intentions stated by the Government, especially in its industry, STI, and education policies.

It is hoped that the findings, implications and recommendations will be sources not only for informed discussion of STI policy, but also the foundation for designing business plans and management actions for implementing innovation policy in support of the Ghana Industrial Policy.

# 4.0 Acknowledgements

The GNSI survey and Report would not have been possible without the close collaboration of key personnel from the GoG, Ministry of Trade and Industry (MoTI), the United Nations Industrial Development Organization (UNIDO) and other Ministries of the GoG, namely the Ministry of Environment, Science and Technology, Education.

Profound expressions of appreciation and special gratitude are extended to the Director-General of UNIDO, Dr. Kandeh K. Yumkella; the Honourable Minister of Trade and Industry, Ms. Hanna Tetteh for making generous resources available for the execution of the Survey and actively participating in the project; and, to UNIDO for providing funding resources and supporting the project team.

The GNSI survey, data analysis and results presented in this Report, have been performed, analysed and authored by Mr. Frank L. Bartels – UNIDO Staff Member, and Mr. Ritin Koria – UNIDO Consultant. Research support, analytical studies, documentation services, and textual analysis of secondary services were efficiently provided by the project team members whose collective efforts are very much appreciated. UNIDO Research Associates, Ms. C. Afrane, Ms. J. Brew and Ms. A. Debrah, provided research support in the field in Ghana for operationalising the survey and data acquisition, as well as supervising the textual analysis of secondary sources of policy information. Mr. D. Ponani, Mr. S. B. Saka and Mr. I. S. Simpson, on Ghana National Service tenable at UNIDO field Office, provided analysis of secondary sources and logistical support in the field. UNIDO Research Associates, Ms. M. Bianchetti, Ms. C. Di Michele, Ms. E. Maggioni, Mr. F. Napolitano and Ms. G. Russomando, very ably assisted in data analysis and other analytical studies, and documentation services at UNIDO Head Quarters, Vienna. Mr. L Brassaw is thanked for editorial work.

Appreciation is also extended to the staff of the office of the then UNIDO Representative in Ghana, Mr. F. L. Bartels, namely, Ms. G. Kyei-Boateng, Mr. M. Wemegah, Mr. F. Agbley and Mr. D. Osekre, whose efficient administrative and logistical support made the project execution all the more effective. Mr. Y. Modenou is thanked for providing ICT support for the interactive video conferencing during training of counterparts. Special thanks go to the current UNIDO Representative in Ghana, Mr. Frank Van Rompaey, for his facilitating engagement with the Project.

MoTI and UNIDO are also especially grateful to all the respondents: Government policy-makers, Chief Executives of Business Enterprises, Leaders in Knowledge-Based Institutions, and Directors of Financial Institutions, Venture Capital and Knowledge Brokering firms, for participating in the survey.

# 5.0 Executive Summary

This report, The Ghana National System of Innovation – Measurement, Analysis and Policy Recommendations, surveys and depicts for the benefit of policy-makers, the essential and systemic features of the landscape of innovation and innovativeness in Ghana. It is the result of 18 months of project execution by UNIDO in concert with MoTI and key stakeholders in Ghana, the Kwame Nkrumah University of Science and Technology (KNUST), and the Science and Technology Policy Research Institute (STEPRI). The analysis, implications and recommendations need to be viewed in the light of the generally unprecedented economic performance of Africa in general, and Ghana in particular, for example Ghana's attainment of middle-income status, and its projected GDP growth rates of around seven percent per annum through to 2016[1].

The analysis of GoG policy documents; mapping and measurement of the GNSI in terms of analysing; linkages between (and within) Actors, barriers to innovation, and success of policy instruments (in relation to barriers to innovation and factors of policy success) discloses key policy analysis findings; major implications from the analysis, and core recommendations that stem from the policy implications of analysis.

The gist of the report points to the GNSI being fragile with an asymmetric distribution of Actor linkages and low density relationships between the Actors.

The dynamics in, and properties of, the GNSI are measurably and highly significantly characterised by truncated, perforated and, in several instances, absent Actor linkages. This overall weakness is exacerbated by really high barriers to innovativeness and exceptionally high constraints (organisationally as well as systemically) on innovation that choke the rate of innovativeness in economic activity. The policy instruments that are available are neither calibrated nor configured to overcome successfully the barriers to, and constraints on, innovation.

The overarching findings from the GNSI survey analysis are four fold. First, the GNSI suffers from low concentrations of Organisational Capital which prevent system wide combinations of skills and assets from delivering significant productivity increases based on science, technology, engineering, mathematics and information technology. Secondly, the quality of Market Demand is hallmarked by few islands of sophistication in a sea of simplicity. This dissuades the manufacturing and service sectors from innovating in order to offer products of enhanced qualities and value. Thirdly, the Organisational Constraints within the GNSI and its Actors are unusually high. These constraints, in terms of managerial rigidities and investment risks, in concert, thwart adaptive behavior and prevent Actors from responding to market signals. Fourthly, the application of Fiscal and Monetary schemes falls short of supporting fully the risk appetite of innovators and businesses in the early stages of ideation, invention and start-up.

At the finer grain level, the Report finds that the crucial linkages between Research Institutions (the principle sources of ideation and invention) and the production system of the country are largely absent. This separation when coupled with the isolation of the Government, Business Enterprises, Knowledge-Based Institutions and Arbitrageurs (Financial Institutions and venture capital) from each other creates serious dysfunctions in the role of Research Institutions. The traditional relationships within Knowledge-Based Institutions (Research Institutions and Higher Education) and with Government, found to be very strong, result in few externalities; especially in the light that Government has no significant assessment of the strength, distribution and density of other Actor linkages.

Regarding Actor linkages and the level of innovativeness in Business Enterprises, the Report finds significantly that all four Actors have extremely weak inter-, intra-linkages and very low levels of Business Enterprises innovativeness coincide to render the GNSI largely inefficient.

Lastly, the Report finds that, concerning policy remedies, policy instruments are generally unsuccessful either in overcoming barriers to innovation or addressing Organisational Constraints. While the Report acknowledges that policy

[1] Economist Intelligence Unit, Country Report Ghana, 29/August/2012

success is determined by a judicious mix of direct (Fiscal and Monetary) and indirect (standards based regulation) support measures, it also finds that available policy instruments are not successful. As a result the GNSI is, to a large extent, ineffective.

The major implications of the above findings are that the little or no externalities from the public goods of funding Research Institutions, aggravated by the absent nexus of innovation policy and industrial innovation, amplifies the sense of discordance in the relationships pertinent to innovation in national economic life. The isolation of Actors renders them respectively independent of the policy making process in terms of influence in calibrating policy to industry needs on the one hand and, on the other hand, exploiting knowledge as well as intermediating the flows of technical know-how.

Furthermore, the respective seclusion of the Actors in the GNSI means that while Business Enterprises have little access to external sources of ideation, Knowledge-Based Institutions have highly restricted outlets through intermediation and commecialisation to markets. This mismatch leads to poor market intelligence, and particularly to a misalignment of strategic research and development operations with the needs of Medium- and High-Tech Industry. The available stocks of Data, Information, Statistics and Knowledge (DISK) remain unexposed and flows of DISK within the GNSI are glacial. Barriers to innovation aligned with poorly configured and inadequately calibrated policy instruments imply incompatibilities and disharmonies in the GNSI that have to be tackled economy- and system-wide, as well as at the level of Actor-specific interventions.

Finally, the findings point to the lack of policy mapping of the GNSI for policy assessment, monitoring and evaluation over the long-term.

The core recommendations of the Report group into four orientations namely; institutional, policy, incentivisation and performance. First, it is strongly recommended that the MoTI and the Ministry of Environment, Science and Technology should become super ordinate as the primary formulator and coordinator of all GNSI related policy and strategy. The vehicle for operationalising this responsibility should be a statutory inter-ministerial GNSI Policy Unit chaired by the two Ministers and reporting to Cabinet. In addition a Science, Engineering, Technology, and Innovation Research Council should be created and chaired at the Vice-Presidential level to re-strategise the purpose and functioning of national agencies. These institutions will impart coherence to the dynamics of the GNSI.

Secondly, in order to address barriers to innovation and innovativeness, policy instruments should be reconfigured and recalibrated to performance-based funding, structures and measures. This will condition, over time, the improvement of innovation behavior of GNSI Actors, especially Research Institutions.

Thirdly, direct and indirect support and incentives to GNSI Actors should be conditional on: engagement of Medium- and High-Tech Industry with Knowledge-Based Institutions and vice versa; triangulation between non-Government Actors with respect to human capital mobility, intermediation, and intellectual property rights in relation to Government contracts and public procurement terms and conditions. Such conditionalities will thicken and intensify inter-, and intra-Actor linkages and reduce asymmetries in the GNSI.

Fourthly, the Report recommends a significantly stronger emphasis (with concomitant political will and financial support) on science, technology, engineering, mathematics and information technology as well as on the use of standards to increase the sophistication of the supply-side and market-demand and regulation to eliminate bottlenecks in doing business. Furthermore, a promising local companies in Medium- and High-Tech Industry identification and support programme should be initiated. These performance oriented recommendations, reinforced by an audit of the current policy mix for fitness-for-purpose and the adoption of the UNIDO NSI methodology for longitudinal policy, monitoring, assessment and evaluation, will drive the GNSI towards markedly greater reliability and stability in delivering higher levels of innovation to the national economy.

The Report recognises the value of survey instrumentation and the crucial importance of measurement as the basis of evidence-based policy management. In this respect, the reapplication of the UNIDO methodology of mapping and measuring the GNSI in two to three years to ascertain the effects of policy choices and implementation on the GNSI, and hence innovation and innovativeness in the economy of Ghana, is advised.

In putting forward the analysis, implications and recommendations, the sovereignty of the GoG is fully respected. The policy implications and recommendations would need to be considered holistically. Also, the final selection of recommendations and the resources to be applied in implmenting policy on innovation is a matter of sovereign choice by, and priorities of, the GoG.

# 6.0 Introduction

The GNSI survey is contextualised by the 2007 African Union (AU) 8th Summit on Science and Technology and Scientific Research for Development, and the GoG's "Ghana Industrial Policy" (GIP) launched in Accra, 1/June/2011, by the Honourable Minister of Trade and Industry, Ms. Hanna S. Tetteh.

The 8th AU Summit, in its declarations, accepted the pivotal role of Science and Technology – and by implication innovation – in socio-economic development. The GIP, component two, Technology and Innovation – Technology, Innovation, Research and Development for Industry, localises the pivotal role of innovation within the national economy.

This Report is crafted to generate advantages for the GoG in policy-making with regard to innovativeness and innovation in the setting of the national economy. It is therefore necessarily analytically intense and draws attention to the statically significant areas of strengths, weakness and fragility, as well as points of vulnerability and liability in the NSI. This attention is expressed without value judgment, in full respect of the sovereignty of the GoG.

The purpose is firstly to inform, with evidence, the national debate on innovation. Secondly, to enable the GoG to consider strategic, operational and tactical policy choices. Thirdly, to enable the GoG to deploy available resources in a prioritised and sequential manner either to concentrate on reinforcing strengths and/or overcoming weaknesses.

Given the complexity and emergent characteristics of the GNSI, the report achieves this purpose by: (i) Providing a statistically significant set of tools, resources and metrics with which policy management can be mapped and measured through evidence-based data and analysis; (ii) Explaining the institutional and structural challenges faced in the policy management of the GNSI; (iii) Setting out key ideas, insights and examples from research and evidence from the survey; and, (iv) Delineating key principles for GoG policy-makers and the supporting policy community in Ghana. This is summarised as analysis, policy implications and policy recommendations.

In the management of the GNSI, policy-makers confront four major issues: (i) The need to better comprehend the increasing pressures of decision-making; (ii) The dynamic tension between evidence, heuristics, practice and theoretical considerations; (iii) The paucity of data availability; and, (iv) The need for evidence-based pragmatic approaches that provide insights for decision-making.

The Report portrays therefore, for policy management, the patterns and dynamics that characterise the GNSI, the relations of the Actors (and their collective behaviour) and the interconnectedness of the elements of the GNSI. In digesting the Report, policy-makers need to take into account the following key ideas: (i) The GNSI is characterised by a complex system of elements that are differentially interdependent, interconnected by multiple feedback mechanisms, and that system-wide behaviour emerges from accumulated interactions among the parts; (ii) In complex systems (Allen., 2000), processes of change are highly sensitive to conditions and can shift dramatically with non-linear tipping points (points of policy leverage); (iii) As a complex (ultimately human) system the GNSI is operated by 'adaptive agents' that act to maximise their interests and managerial utility, who network, react to and influence other Actors in the system, respectively. Enhancing the adaptive response capacities and capabilities of these networks through policy levers is essential to strengthening resilience, innovativeness and innovation.

The Report is based on empirical, data-driven statistically significant analysis to provide rigorous evidence-based insights. The following seven principles guide the policy analysis, implications and recommendations: (i) One cannot manage what is not measured and what gets measured gets done; (ii) Understanding the systemic nature of the GNSI; (iii) Involving those Actors that matter the most in decisions that are crucial to the effectiveness and efficiency

of the GNSI; (iv) Avoiding 'one size-fits-all strategies' and embracing multiple policy instruments; (v) Establishing real-time longitudinal analysis and learning as key to operational effectiveness; (vi) Openness to adaptation of effort to local conditions; and, (vii) Framing the policy management of the GNSI as a dynamic network involving a multilateral system of Actors. With these principles, a more innovative, relevant and appropriate approach to the policy management of the GNSI is possible.

## 6.1 Ghana National System of Innovation (GNSI) Survey Project Provenance

The GNSI Survey Project emerges from the GoG recognising the need for a more coherent approach to policy with respect to innovation within the national economy. The Report is mandated by the request of 24 August 2010, by the MoTI of the GoG to UNIDO for Technical Cooperation assistance to carry out Ghana's first NSI survey.

In December 2009, and September 2009, MoTI and Environment Science and Technology (MEST) developed the following policy documents, respectively:

- *The Science, Technology and Innovation Policy Document (STIP) (September 2009)*, and
- *The Ghana Industrial Policy Document: Policy Prescriptions for Technology and Innovation (December 2009).*

In a letter to UNIDO dated 29 October 2009, MEST requested UNIDO, regarding the STIP document, for "inputs from key stakeholders, institutions and development partners [...] for your inputs and feedback."

The recommendations made by UNIDO to MEST regarding the STIP document stated that: (i) There was no mention of the NSI approach to science, technology and innovation policy, and this had to be included for policy coherence; (ii) Key dimensions of NSI, namely measuring STI policy variables across GNSI Actors, needed to be incorporated for implementing viably the policy; (iii) The indicated weakness of, and constraints to, STI, which were neither measured nor quantified, needed to be quantifiably measured for policy purposes of implementation; (iv) A full appreciation of measuring the inter-linkages between Actors in NSI (Government, Knowledge-Based Institutions and Medium and High-Technology Industry) needed to be incorporated; (v) Policy implementation requires analytical studies in the form of periodic surveys of the GNSI; and, (vi) UNIDO has methodology for longitudinal surveys of NSI and the STIP document, and its policy implementation would benefit from such.

Neither of the documents mentioned above projected the measurement of STI variables, all of which are crucial for coherent implementation and monitoring of policy and its prescriptions.

In addition to the aforementioned, the Medium Term National Development Policy Framework (MTNDPF): *Ghana Shared Growth and Development Agenda (GSGDA I), 2010-2013*, sets out specific targets with which to enhance the Ghanaian private sector.

In order to bring about an investment climate that broadens investment and encourages greater enterprise and innovation, the MTNDPF will focus on the following key strategies:

- "Invest in available human resources with relevant modern skills and competences" (p.135);
- "Invest in science, technology and innovation" (p.135);
- "Government has prioritized Science, Technology and Innovation (STI) as a principal vehicle to drive Ghana's development agenda. However, there are issues of ...lack of a national policy on commercialization of scientific research; weak institutional arrangements to support the development and application of science, technology and innovation; and, lack of science and technology culture in all sections of society." (p.58);
- "The thrust of the STI policy is to harness the nation's science and technology capacity to achieve accelerated economic growth and sustained poverty reduction. The medium-term policy objectives are to: promote the application of Science, Technology and Innovation in all sectors of the economy; and strengthen the appropriate institutional framework to promote the development of scientific and technological research. Strategies to achieve these policy objectives include: encourage the diffusion and transfer of technology; promote the establishment of national science and technology theme parks; promote and establish national systems of innovation to address the technology development cycle; establish a Science and Technology Fund to support research activities in tertiary and research institutions (private and public); provide support for businesses to adopt research and development as a critical component of production; and provide incentives to strengthen research and industry linkage and collaboration." (p. 58); and,
- "...developing a comprehensive programme to improve the capacity of the informal sector; building the capacity of local publishing and printing industries to generate employment;

and establishing a system to identify, promote and reward innovation and creativity at all levels." (p.87)

Again, in order to effectively meet the targets of the MTNDPF concrete measures and indicators are necessary, and yet these are either under emphasised or missing in *The Ghana Industrial Policy Document: Policy Prescriptions for Technology and Innovation, and The Science, Technology and Innovation Policy Document (STIP)*. These policy framework measures and their inter-relationships would be provided by the GNSI Project.

The MTNDPF evokes the institutionalisation of the GNSI, meaning the uptake of methodologies and the creation of capacities for repeating the survey will be achieved through sensitisation to, and conducting, project activities, bearing in mind that conducting the project itself is an institutionalisation process. The first step in this process has been the commitment made by the Government of Ghana in identifying specific focal points and assigning time to the project.

## 6.2 What Has Been Done

The GNSI Survey has been executed in the light of the UNIDO Survey of Surveys of Innovation (2007 updated in 2012) in Emerging Market Economies (EMEs). The finding being 128 surveys of innovation, none of which is strictly a National System of Innovation Survey.

The Data Acquisition Survey Instrument (DASI) for the GNSI Survey was created using an iterative multi-step process. The first steps involved a survey of NSI literature (as well as a trawl of all innovation surveys since 2000) in 2007 by the UNIDO Statistical Research and Regional Analysis Unit. From this initial work, 300 comprehensive variables were extracted, which were then further reduced to 138 variables[2] (Bartels, et al., 2009). Using this extraction as a foundation, an initial perceptions-based survey instrument of NSI was created. In order to measure Actor perceptions and enable Respondents to express both the direction and strength of their opinion (Garland, 1991; Clason and Dormody, 1994) a five-point Likert scale was used. There is strong empirical evidence that supports the treatment of ordinal variables as conforming to interval scales (Labovitz 1967, 1970, 1971). The survey was then refined through a process of peer review[3]. This version of the DASI will herein be referred to as DASI-V1.

[2] Through this comprehensive review of literature the objective is to achieve a high level of internal and construct validity

[3] In the process, the questionnaire was sent to Prof. J. Howells at the Centre for Research on Innovation and Competition (CRIC), U.K. and Prof. S. Mani at the Centre for Development Studies, India, for peer review, additional suggestions and inputs.

The DASI-V1 was then reverse translated into French and Spanish for the sake of accuracy and embedded into an electronic medium (Lime Survey) so as to create a web-based, electronic questionnaire. In an effort to reduce measurement error, questions were kept concise and definitions provided in help boxes where necessary. The details and choice of medium will be explained in greater detail later in this chapter.

The electronic DASI-V1 was then pilot launched in seven Emerging Market Economies (EMEs), namely, Egypt, Morocco, Chile, Peru, Malaysia, Thailand and the Ukraine. The selection of these countries was made on the basis of the Survey of Surveys of Innovation[4] which looked at innovation surveys conducted in EMEs as classified by Institute of International Finance (IIF). Egypt, Morocco, Chile, Peru, Malaysia, Thailand and the Ukraine, were chosen because either no survey had been conducted, or not for a long time.

Figure 6.1 below – Methodological Framework for GNSI Survey – illustrates the logic of the UNIDO methodology with respect to the GNSI Survey.

UNIDO uses an innovative remote DASI which has been operationalised and tested "in-house" and in African countries (The Manu River Union countries, and Morocco and Egypt). The approach consists of the following operational methodology (See Figure. 6.2 below) where numerous steps will have been taken to ensure validity, reproducibility and maximal response rate (Karlen et al., 2010).

## 6.3 Areas of Coverage

In order to place the GNSI Survey into perspective, UNIDO conducted a Survey of Surveys of Innovation EMEs in 2007, and again in 2012. The updated Survey of Surveys of Innovation shows that of the 128 surveys that had been conducted since 1990 in EMEs, none could be strictly defined as an NSI Survey, in terms of the same DASI being applied to the constituents of the NSI[5], namely: leadership (Minister, Deputy Minister, Chief Director) in Government policy-making; high-level management (Chief Executive Officers) in Medium High-Tech Industry (MHTI); leadership (faculty deans and departmental heads) in Knowledge-Based Institutions (KBIs); and leadership

[4] The Survey of Surveys of Innovation was conducted by Ms. Simone Carneiro, UNIDO consultant in 2007

[5] Etzkowitz, H., 2003. Research Groups as 'Quasi-firms': the Invention of the Entrepreneurial University. *Research Policy*, 32, pp.109-121; Leydesdorff, L., 2005. The Triple Helix Model and the Study of Knowledge-Based Innovation Systems. *International Journal of Contemporary Sociology,* 42(1); Shinn, T., 2002. The Triple Helix and New Production of Knowledge: Prepackaged Thinking on Science and Technology. Social Studies of Science, 32(4), pp.599-614; Leydesdorff, L., and Meyer, M., 2006. Triple Helix Indicators of Knowledge-Based Innovation Systems: Introduction to the Special Issue. *Research Policy*, 35, 10, pp.1441–1449; Kapsali, M., 2010. Relating in Project Networks and Innovation Systems. In: DRUID (Danish Research Unit for Industrial Dynamics), *Summer Conference on Opening up Innovation Strategy, Organization and Technology*. London, UK 16-18 June 2010.

*Figure 6.1 – Methodological Framework for GNSI Survey.*

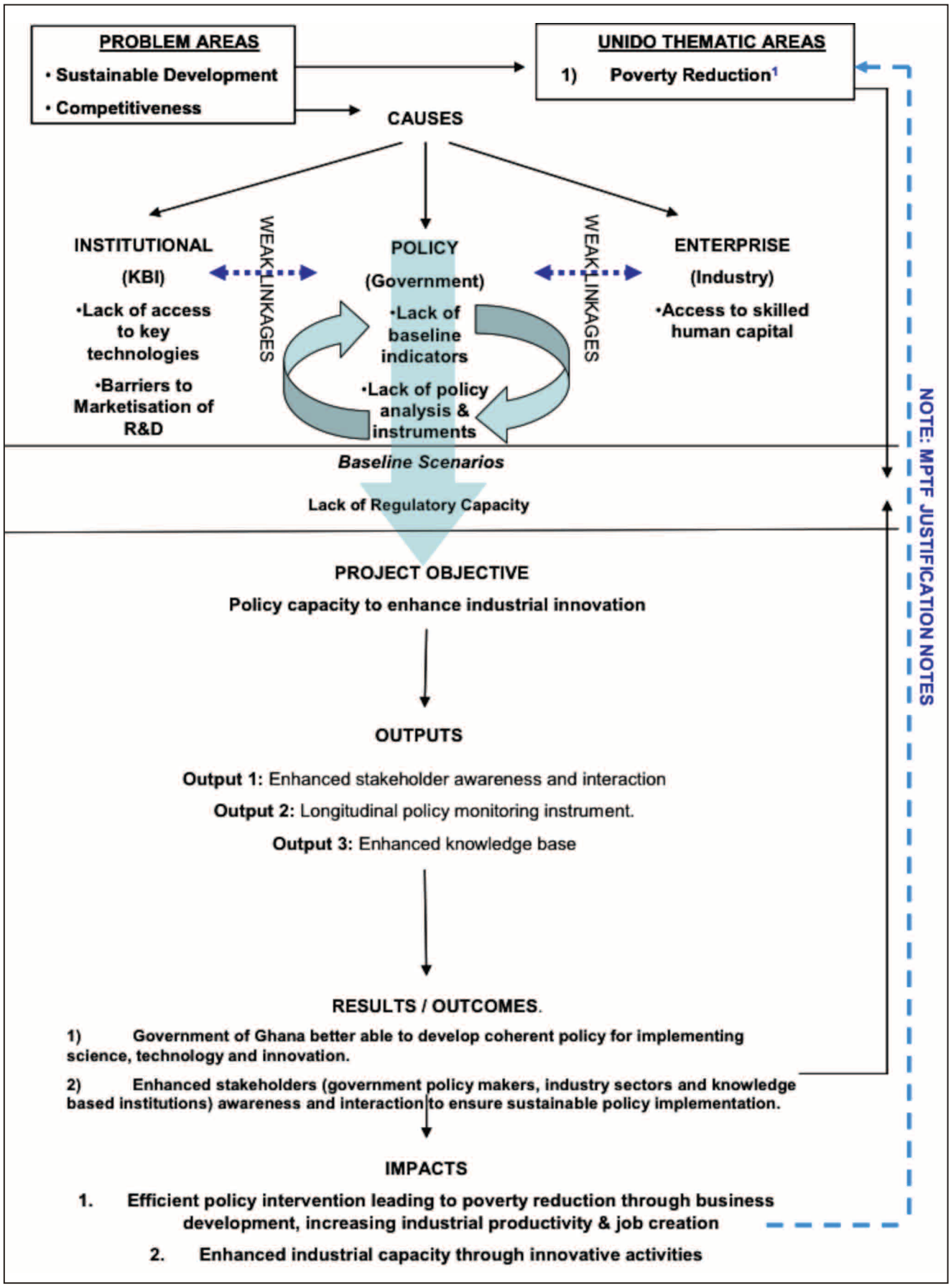
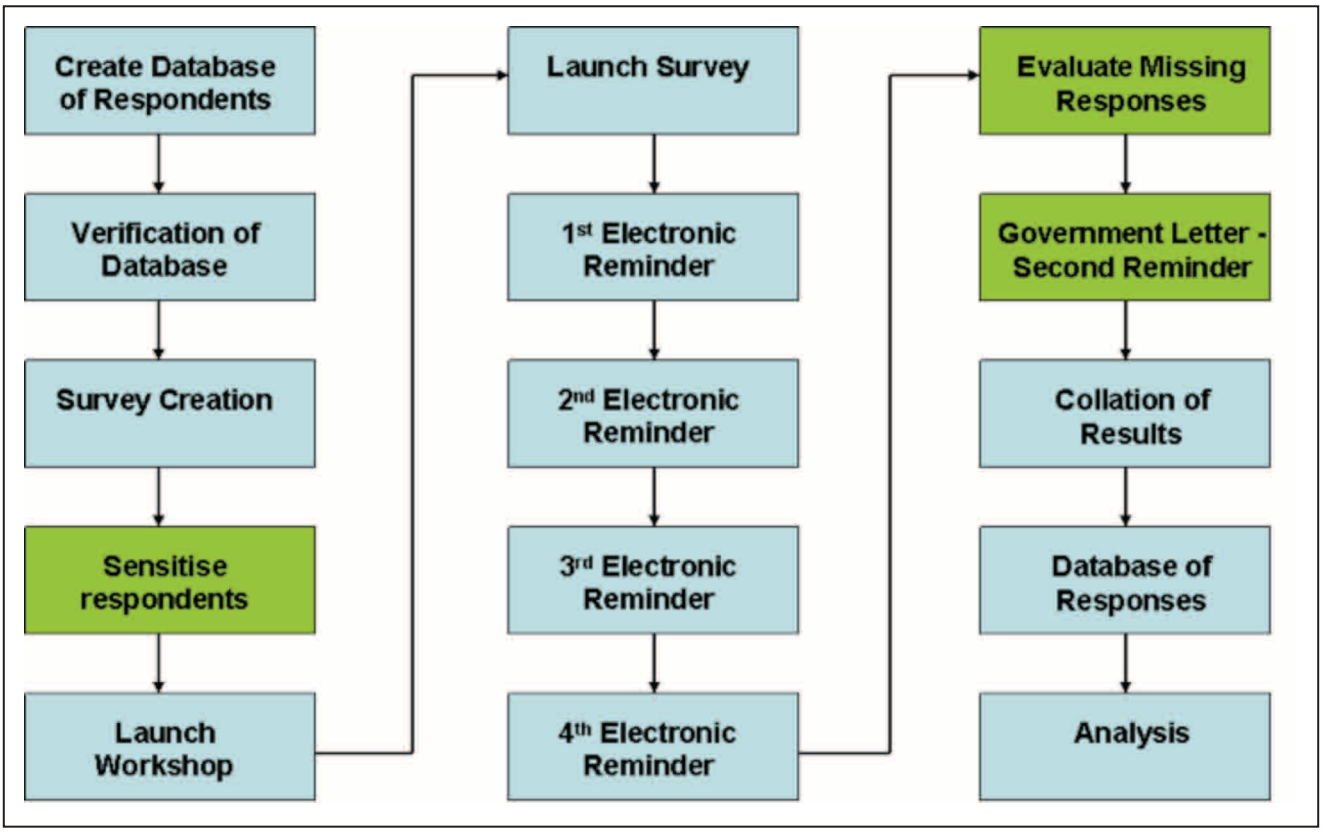


***Figure 6.2*** *– Methodological Framework for GNSI Survey.*




(Chief Executive Officers) in Arbitrageurs (ARB), Financial Institutions (FI), Venture Capital, and Knowledge Brokers. A breakdown of the 128 surveys conducted indicates: 60 in Emerging Europe, 34 in Latin America, 19 in Asia, and 15 in Africa and the Middle East.

The GNSI Survey applies the same DASI to the three constituents of the NSI, as well as to a fourth actor, namely Arbitrageurs, who are acknowledged to play a crucial role of intermediation between sources of knowledge and commercialisation of knowledge[6]. UNIDO is confident that the GNSI Survey is the first of its kind[7]. It should be noted that the 2009 report, The Ghana Innovation Survey, by Science and Technology Policy Research Institute (STEPRI), August 2010, surveyed 116 firms or enterprises. The UNIDO GNSI Survey obtained valid and reliable responses as shown in Table 6.1 below.

## 6.4 Types of Documents Covered

In order to arrive at a comprehensive view of the policy orientation of the GoG with respect to STI within the national economy, a number of GoG policy documents were reviewed and textually analysed. The results of the analysis are presented in Chapter 8 of this Report. The analysis shows the extent to which there is commitment to the role of STI within the economy, as well as the policy orientation. By way of signaling Chapter 8 in general, there is either an under-emphasis or an absence, in the policy documentation of targets, and in indicators for achieving the targets and monetary and fiscal dimensions to the targets.

The following documents were analysed:

- *The Ghana Industrial Policy* (2011).
- *The National Science, Technology and Innovation Policy* (2010).
- *The Industrial Sector Support Programme 2011-2015* (2011).
- *The Ghana ICT for Accelerated Development (ICT4AD) Policy* (2003).

[6] As such, knowledge brokers and venture capitalists fill this gap through the provision of links, knowledge sources and even technical knowledge so that firms can improve their performance in terms of survival rate as well as accelerate and increase the effectiveness of their innovation processes (Zook, 2003; Hargadon, 1998; Baygan and Freudenberg, 2000). Their resource allocation role is based on the assessment of advantages in information asymmetries (Williamson 1969, 1971, 1973; Bartels, et al., 2012 p.7). In the Triple Helix type 4 it is posited that the arbitrageur interacts, primarily as an inter-mediator, with Industry, KBIs and Government and not only provides the necessary financial, legal and information inputs to the system but also, when appropriate, assumes equity position, mentoring and other investor roles.

[7] Bartels, F.L. Koria, R. and Carneiro, S., 2009. National Systems of Innovation in Selected Emerging Market Economies: an Examination of Actors, Interactions and Constraints. In: EAMSA (Euro-Asian Management Studies Association), *26th Conference on Globalization of Technology, Innovation and Knowledge.* Lausanne, Switzerland 22-24 Oct. 2009.and Knowledge. Lausanne, Switzerland 22-24 Oct. 2009.

***Table 6.1-*** *GNSI Universe and Convenient Sample of Respondents*

| Actor | Universe | Convenient Sample | Responses | Response Rate (%) |
|---|---|---|---|---|
| Government | 260 | 166 | 39 | 33.6 |
| MHT Industry | 120 | 87 | 60 | 68.9 |
| Knowledge-Based Institutions | 182 | 175 | 129 | 73.3 |
| Arbitrageurs (Financial Institutions, Venture Capitalists/Knowledge Brokers) | 16 | 16 | 6 | 37.5 |
| All Actors | 578 | 444 | 234 | 52.7 |

*Note: the convenient sample represents Respondents whose contact details were verified through the UNIDO verification protocol.


- *Government of Ghana, 2005. Ministerial ICT Policy Statements* (2005).
- *The Ghana Shared Growth and Development Agenda (GSGDA) I & II,* 2010-2013 (2010).
- *The Ghana Trade Policy* (2005).
- *The Ghana - Vision 2020 (1995). The National Policy on Public-Private Partnership* (2011).
- *The National Science, Technology and Innovation Development Programme of Ghana (STIDEP) 2011-2015* (2010).
- *The Ghana Poverty Reduction Strategy (GPRS) I, 2003-2005* (2003).
- *The Ghana Poverty Reduction Strategy (GPRS) II, 2006-2009* (2005).
- *The Preliminary Education Sector Performance Report* (2008).
- *The Education Strategic Plan I & II, 2003-2015* (2003).
- *The Education Strategic Plan I & II, 2010-2020* (2010).


## 6.5 Structure of The Report

The Report is structured in 11 chapters, the substantive being Chapter 5 – Executive Summary – which presents the salient features, key findings and messages of the Report. Chapter 6 – Introduction – introduces the Report in terms of context, purpose, and guiding principles. It indicates provenance, activities undertaken, areas covered and documents analysed, etc. Chapter 7 – Overview of the NSI Concept and Introduction of the 'Triple Helix' Type 4 – presents the rationale and analytical framework for approaching the study of NSI. It indicates the evolving definition of the term NSI as well as the relationship between the NSI, its Actors and economic development. Chapter 8 – Country Level Coherence – portrays the articulation of national policy priorities with respect to science, technology and innovation. The chapter reviews innovation policy with respect to industry, science, technology and Information and Communications Technology (ICT), as well as education. Chapter 9 – Policy Analysis, Implications and Recommendations – presents the overall policy analysis in terms of the statistically significant analytical results. It discusses the policy implications and suggests policy recommendations. Chapter 10 – Policy Recommendations Matrix – presents the policy recommendations in terms of a policy matrix framed in time and space. The policy matrix provides a 'helicopter' view of the GNSI policy landscape in terms of priorities, targets and measures for implementing policy on innovativeness and innovation. Chapter 11 – References – lists the sources of empirical and theoretical foundations that have underpinned the survey work, data analysis and data interpretation to arrive at policy recommendations.

# 7.0 Overview of the NSI Concept and Introduction of the 'Triple Helix' Type 4

This chapter introduces the conceptual and empirical basis for addressing the NSI as a crucial matter of policy concern. Innovation is increasingly viewed as the salient ingredient in the sustainable growth of the modern economy. A nation must access information and develop technological capacity, and hence industrial productivity capabilities, if it does not wish to find itself on the down side of the cross-country income distribution (Quah, 1996, 1997; Jones, 1997).

The rate of technological innovation and quality of competitive advantages generated by the NSI are ultimately determined by factors such as the intensity of inter- and intra- organisational relationships between, and within, key Actors; the level of available resources and policy management of co-operational and conflictual contexts that arise because of agency problems and managerial utility in, and among, Actors. These relationships determine the coherence of the data, information, skills and knowledge available, as well as their inter-linkages and reciprocating exchanges of value among key Actors in the NSI. Concepts and explanations that underpin the policy awareness of the dynamics of economic and social development through innovation are increasingly systemic (Antonelli, 1999; Cohendet, et al., 1999). The conceptual and empirical articulations are framed in terms of understanding networks and interactions as Complex Adaptive Systems (CAS), with respect to properties of non-linear systems, knowledge generation and flows (Bartels, et al., 2012; Bartels and Voss, 2005; Bartels and Lederer, 2009; Nelson and Winter, 1982; Dosi, et al., 1988; Leydesdorff and Van den Basselaar, 1994).

The NSI is one such non-linear phenomenon that can be managed through evidence-based policy analysis. Complex Adaptive Systems, broadly speaking, are systems that exhibit emergent behaviour due to interactions between their component elements. They are characterised by interconnectedness, feedback loops, non-linear change and tipping points, and emergent properties at the macro-level which need to be understood holistically.

A perspective provided, at the turn to the 21st century, by the 1999 Conference on "National Innovation Systems, Industrial Dynamics and Innovation Policy" (DRUID, 1999), showed that the taxonomy of NSI encompassed at least eight dimensions. These included: methodological; knowledge; learning; organisational, inter-industry and inter-firm linkages; growth and industrial renewal; NSI in developing countries; globalisation and NSI; and NSI policy. The 2012 Conference on "Innovation and Competitiveness: Dynamics of Organisations, Industries, Systems and Regions" (DRUID, 2012) shows that the concept and empirics of NSI nowadays encompasses 15 dimensions. These are: Systems of Innovation; Markets and Entrepreneurship; Organisational Strategy and Innovation; Firm theory and empirics; Knowledge Networks; Intellectual Property Rights; KBIs and Governance; Eco-Innovations; Innovation under Financial Crises; Organisational Creativity; Institutional Dynamics; Labour-Capital Mobility; Regional Clusters and Growth; Public-Private Partnership Policy; Innovation and Economic Development. These further dimensions denote the evolution and dynamism of NSI, and the contribution to economic competitiveness. They also shed light on why considerable efforts have been made by several countries to measure the dimensions, factors and variables of innovation, and by implication NSI effectiveness, efficiency and performance at varying levels (meta, macro, meso and firm)[8].

At the meta level, the global aspect of NSI and internationalisation of alliances between firms and networks especially with respect to technology, R&D activities is illustrated by Archibugi and Iammarino (1999), Blanc and Sierra (1999) and Carlsson (2006)[9]. Their findings highlight the important role of KBIs, namely universities, private and public

[8] A Survey of Surveys of Innovation in 30 emerging market economies carried out by UNIDO in 2007 and updated in 2012 shows that 128 such surveys have been performed since 1990. However none of these surveys is a National System of Innovation Survey. All the Innovation Surveys were targeted only to Respondents from industry. In contrast, a NSI Survey targets government policy leaders; leaders in knowledge-based institutions; chief executives of firms in medium- and high-technology industries; and chief executives of arbitrage and venture capital companies.

[9] For a recent review of the NSI concept, see Lundvall (2007). See also Dunning, J.H., 1997. Alliance Capital and Global Business. London: Routledge, for an appreciation of the increasing networked nature of international businesses including the offshore outsourcing of knowledge work.

research centres, engaged with international firms in research based techno-scientific collaborations. These Actors - plus Government - are the core of the NSI as a "neo-evolutionary" model of university-industry-government interactions, known as the "triple helix" (Leydesdorf, 2001). A secondary perspective at the meta level adds two further aspects to the description of NSI, namely informality/formality and distance from the innovation process. Informality is central to networking and the development of the social capital that lubricates formally the functioning of the NSI (Bartels, 2005; Schoser, 1999). A characterisation of NSI at the macro level leads us to the work of Bjørnskov and Svendsen (2002) who use decentralisation and social capital to demarcate the notable economic performance of Scandinavia. In contrast, Asheim and Coenen (2004) and Munk and Vintergaard (2004) develop a meso or cluster-based taxonomy in which the importance of the knowledge base and the nature of organisational capital, and institutional characteristics and involvement in innovation are key factors. Narrowing the focus further to the firm level, Braadland and Anders (2002) include skills and the systemic nature of innovation in their classification of NSI. These varying approaches that characterise NSI reflect differing purposes of inquiry, focus, and policy.

To delineate the NSI we look at the evolution of the definition of NSI in order to inform the policy rationale for carrying out the GNSI survey .

"[...] the network of institutions in the public and private sectors whose activities and interactions initiate, import, modify and diffuse new technologies." (Freeman, 1987, pp.1)

"[...] the elements and relationships which interact in the production, diffusion and use of new, and economically useful knowledge [...] and are either located within or rooted inside the borders of a nation state." (Lundvall, 1992, p.2)

"[...]a set of institutions whose interactions determine the innovative performance [...] of national firms." (Nelson and Rosenberg., 1993, p.4)

"[...] the set of institutions and economic structures affecting the rate and direction of technological change in the society." (Edquist and Lundval, 1993, in UNIDO, 2005, p.10)

"[...] the system of interacting private and public firms (either large or small), universities, and government agencies aiming at the production of science and technology within national borders. Interaction among these Actors may be technical, commercial, legal, social and financial, in as much as the goal of the interaction is the development, protection, financing or regulation of new science and technology." (Niosi, et al., 1993, p.212)

"[...] the national institutions, their incentive structures and their competencies, that determine the rate and direction of technological learning (or the volume and composition of change generating activities) in a country." (Patel and Pavitt, 1994, p.5)

"[...] that set of distinct institutions which jointly and individually contribute to the development and diffusion of new technologies and which provides the framework within which governments form and implement policies to influence the innovation process. As such it is a system of interconnected institutions to create, store and transfer the knowledge, skills and artefacts which define new technologies." (Metcalfe, 1995, p.38)

"The National Systems of Innovation approach stresses that the flows of technology and information among people, enterprises and institutions are key to the innovative process. Innovation and technology development are the result of a complex set of relationships among actors in the system, which includes enterprises, universities and government research institutes" (OECD, 1997, p.7).

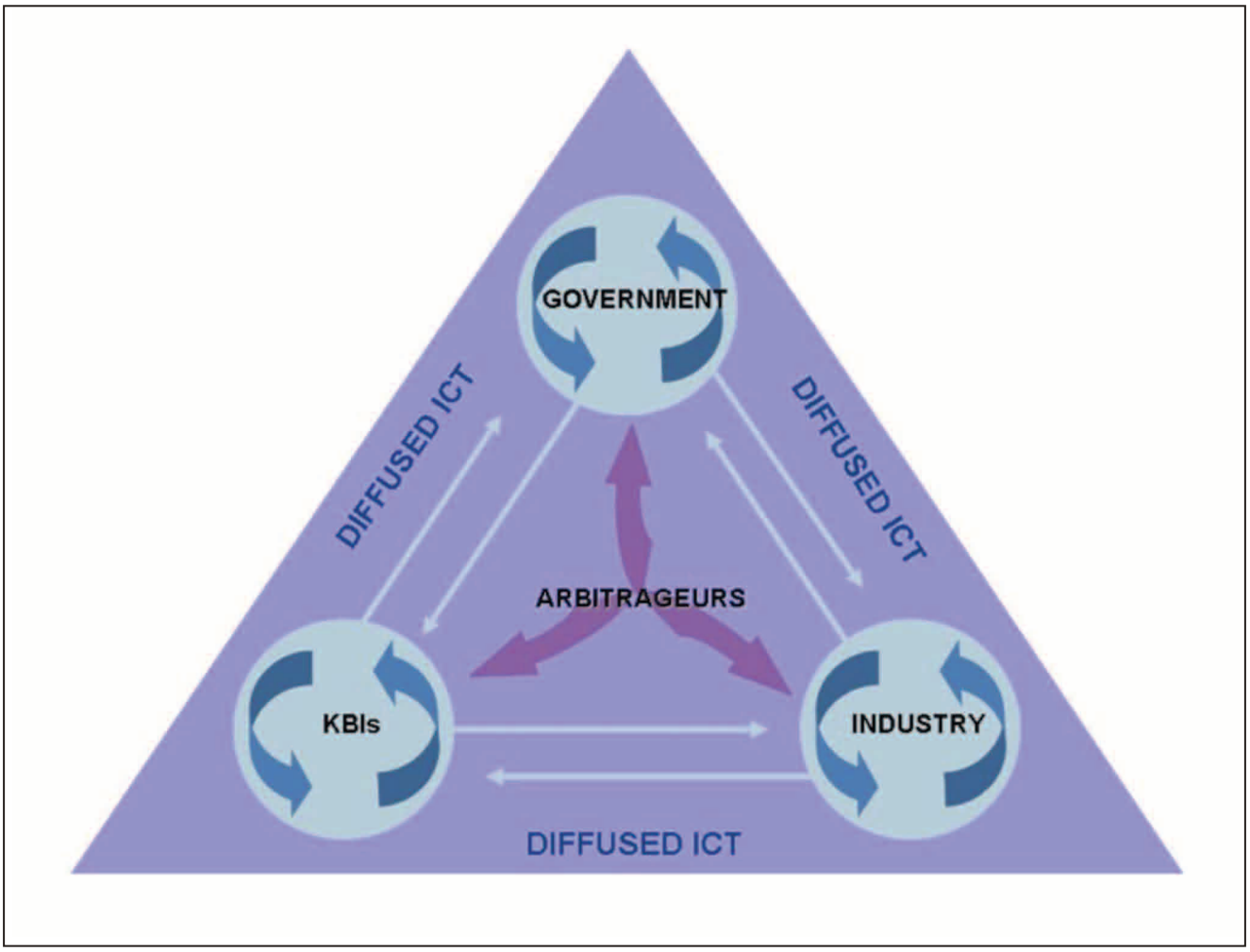
"[...] the envelope of conforming policies as well as private and public organisations, their distributed institutional relations, and their coherent social and capital formations, that determine the vector of technological change, learning and application in the national economy." (Bartels, et al., 2012, p.6)

From the evolution of the definition of NSI, it is evident that there are certain recurring concepts, for example, Actors, organised (formal and informal) knowledge transfer, skills, linkages and interaction, and technological learning and change. The evolving definition of the NSI enables a 'stocks' and 'flows' perspective. In this view, institutions, in the dual sense of organisations as well as the 'rules of the game' (North, 1991), constitute the 'stocks' of the NSI. The transfer of tacit 'know-how' (to the extent possible) and codified knowledge constitutes the 'flows' within the NSI. Phrased differently, NSI consist of linkages (formal and informal) and their intensity between institutions that facilitate intellectual flows and exchange of knowledge resources in the economy (Buckley and Carter, 2004). The fundamental enabling factors for these flows are the policy environment, the rate and extent of learning, and their embeddedness in organisations (taking into account the influence of geography and location) (Marshall, 1920). The effectiveness and efficiency of the stocks of, and flows in, the NSI determine ultimately the technological competitiveness of the national economy.

However, given the definition that alludes to the 'envelope' of conforming policies (Bartels, et al., 2012), there are two aspects that are excluded from the traditional framing of NSI which we include in our framework and methodology. These are namely the effects of diffused ICT, and Arbitrageurs. Through the spread of digital information and ICT a new mode of development has evolved (Perez, 1983; Freeman and Louça, 2001). Our inclusion of ICT in NSI is not based solely on the concept of access, but on the work of Hilbert, et al. (2010) who view the digital divide as being attributable

to issues of storage, the ability to compute and transmit digital information; to contextualise not just the quantity of hardware but also the corresponding performance in relation to all four NSI Actors as depicted in the Triple Helix type 4. Within the developing country context, the three Actors (Government, KBIs and Industry) are perceived to hold relatively traditional and separate roles, with little or no overlap in function, i.e. in contrast to "entrepreneurial academics, academic industrialists, and business strategy in government" (Ekztowitz, 2002, p.117). This is evidenced by the lack of bodies such as technology transfer or licensing offices within universities or widespread venture capitalists. Therefore, access to the necessary financial and information resources would lead to the need for independent institutions, namely Arbitrageurs. Figure 7.1 below illustrates this framework as the Triple Helix type 4. It is the basis for measuring the GNSI, and hence provides the framework for policy analysis, policy implications and policy recommendations in the context of the articulation of national priorities.

***Figure 7.1*** *– Triple Helix Type 4*



# 8.0 Country Level Coherence – Articulation of National Policy Priorities

## 8.1 Overview

This chapter focuses on a selection of GoG policy documents within the framework of the GNSI Survey. These documents are reviewed for an understanding of the interconnected policies the GoG has developed to enhance the role of innovation and competitiveness in the national economy.

Furthermore, this chapter examines the directives established by Ghanaian policy-makers to discern the economy's competitiveness in Technology and Innovation, and how synergies among the four NSI key Actors [Government, KBIs, Industry and Arbitrageurs] can influence policy implementation.

The following sections present textual analysis of three different policy areas. The first reviews policy documents related to industry as a key driver in development. The second provides a contextual analysis on Science and Technology, and ICT in terms of their strategic potential for contributing to socio-economic growth. The third examines the importance of Education, in enhancing Innovation and Technology, as a base for socio-economic transformation in Ghana.

The policy documents selected to highlight the GoG commitment to the role of its NSI in industrialisation are indicated previously in section 6.4 – Types of Documents Covered.

The purpose of this review is a textual analysis of the listed policy documents showing their reference to, and interactions with, the key NSI Actors with regard to how measurable and workable the policies and strategies are with respect to Industry, Science and Technology, ICT, and Education. However, this policy analysis is performed bearing in mind the challenges that Ghana's institutions face and the adaptability of the NSI framework to the Ghanaian socio-economic context. Necessarily, the policy documents inspect key overarching themes and the strategies elucidated also have recurrent schemes for achieving policy objectives.

To elaborate an effective and efficient set of policies for industrialisation, it is necessary to apprehend, through measurement, the linkages amongst the key Actors in the NSI in order to improve Ghana's technological and economic performance. These interactions, if purposefully nurtured and stimulated by the Government, can propel Ghana to higher middle-income status.

## 8.2 Policy Review on Industry

This section gives a broad overview of the industrial policy documents in Ghana with regards to STI in Industry, ICT for Industrial Development, and R&D to enhance industrial growth and to implement the Public-Private Partnership (PPP) agenda of the GoG.

The challenge to accelerate Ghana to higher middle-income status by enhancing industrial productivity and competitiveness has been addressed in several policy initiatives with particular emphasis on STI development.

The objective of increasing Science, Technology, Research and Innovation for industry was stated in the Ghana Industrial Policy (2011). The policy's fundamental aim is to transform Ghana into an industry-driven economy capable of delivering decent jobs with widespread, equitable and sustainable growth and development. The policy "is designed to promote increased competitiveness and enhanced industrial production, with increased employment and prosperity for all Ghanaians" (Ghana Industrial Policy, 2011, p.4). Furthermore, the National STI Policy (2010) objective is to develop STI capacity to support the building and construction sector, including the development of local raw materials and equipment, and to encourage their use in the local building industry (National STI Policy, 2010, p.28).

The GoG has considered the use of ICT as a means to leverage the country's industrial development. Particularly, Ghanaian Industrial Policy identifies that the adoption and effective use of ICT in the manufacturing sector will drive competitiveness (Ghana Industrial Policy, 2011, p. 28). For that reason, the Industrial Sector Support Programme (2011) was designed with the objective of developing a manufacturing sector that is globally competitive. The Ghana ICT for Accelerated Development Policy (2003) acknowledged that Ghana will

need to develop and implement comprehensive integrated ICT-led socio-economic development policies, strategies and plans in industry. Furthermore, the policy framework of the Ghana Shared Growth and Development Agenda I (2010) sets the objective of enhancing competitiveness of Ghana's private sector by increasing the development of national ICT infrastructure in the country.

In order to enable the industrial sector to achieve its contribution to development goals, the Ghana ICT for Accelerated Development Policy (2003) calls for the development of Ghana's R&D capacity and capabilities to enable the development of a globally competitive knowledge-based and high-tech export industry. The Small- and Medium-Sized Enterprises (SMEs) Support Project, under the Ghana Trade Policy (2005), indicates the purpose to upgrade SMEs through incentives and R&D expenditure in supporting the technological development of SMEs. Finally, the "Ghana Vision 2020" encourages R&D as an integral part of all production activities.

The private sector (especially Medium- and High-Tech Industry) is now widely acknowledged as a key partner in enhancing national competitiveness as stated by the National Policy on Public-Private Partnership (2011). The Government has implemented various forms of private-sector engagements including: investment, capacity building, knowledge sharing and innovation (National Policy on Public-Private Partnership, 2011, pp.1-4). The provision of public infrastructure and services is one of the prime mandates of the Government and is most effective when the private sector is involved. Local private companies may therefore rely on the research by Government Research Institutes to build their capacity for quality products' enhancement. The Ghana Shared Growth and Development Agenda I (2010) recognises the role of the private sector as crucial to the growth and transformation of the economy and underlines its responsibility of partnering with the GoG in transforming the industrial economy through the modernisation of agriculture. Additionally, the National STI Policy (revision 2010) indicates that the Government has started initiating public-private partnerships in the application and the development of STI as a key strategy in encouraging private-sector contributions in financing STI initiatives.

Successful implementation of the National STI policy will require determined efforts and synchronisations among the key Actors in the economy (Government, KBIs, Industry, Arbitrageurs). In achieving development objectives of the NSI, the Government directs policy goals, objectives and strategies toward the other Actors to create and strengthen linkages between Actors. In the Government's policy, the focus is on "the expansion of technological capacity and capability in the manufacturing sector" (Ghana Industrial Policy, 2011, p. 4).

It is recognised that the private sector generally has limited or low capacity "to undertake and absorb science and technology for innovation, in order to improve productivity and become more competitive" (Ghana Industrial Policy, 2011, p. 24). Therefore, it is the Government's mandate to enable the private sector to operate effectively through the uptake of STI, in order to enhance competitiveness. Also, the Ghana Industrial Policy underlines that SMEs have a "low capital and human resource base" (Ghana Industrial Policy, 2011, p. 24) in their operations. The Government's mandate is therefore to design policies to support and promote innovation in order to alleviate this particular constraint.

Industry depends on KBIs in terms of acquiring the necessary skills that bring innovation into operations. However, most of these tertiary institutions lack adequate infrastructure for the advanced industrial study of Science and Technology, resulting in a limited skills base in the economy at large (Ghana Industrial Policy, 2011, p.24). For this reason, the development of skills and technical capacity has been truncated in the industrial sector. The Ghana Industrial Policy identifies the role of Arbitrageurs in providing appropriate financial instruments to support industry in harnessing STI operations.

### 8.2.1 Policy Strategies and Incentives

The strategies for promoting STI in the industrial sector include: "the strengthening public research institutions; the raising of the ability of private firms to carryout R&D and absorb technology; the supporting of the outsourcing of Science and Technology requirements" (Ghana Industrial Policy, 2011, p.23).

To achieve the goal of development of STI skills to meet industrial needs, the Ministry of Trade and Industry proposes to "strengthen and expand the provision of business development services and support for industrial firms undertaking and exploiting S&T for innovation" (ISSP 2011-2015, p. 36), and to provide structured incentives for "skills development in public and private sector training institutions, as well as industry associations and at the firm level" (ISSP 2011-2015, p.16).

In order to enhance ICT usage in the industrial sector the Ghana Industrial Policy sets the following strategies: "strengthen existing educational and training institutions to develop the requisite skills to support the application of ICT in manufacturing; [...] promote the development of Technology Parks to facilitate the creation of an effective linkage between ICT, technology transfer and the manufacturing sector; [...] promote the use of ICT for the collection of industrial data from the manufacturing sector; and, [...] promote the development of ICT programmes to link raw material suppliers, manufacturers, marketers and service providers" (Ghana Industrial Policy 2011, p.28). In addition, the policy proposes the "use of incentives and regulatory measures to encourage investments in ICT infrastructure and reduce costs" (Ghana Industrial Policy 2011, p.28).

To promote research and development in the Ghanaian industrial sector, the Ghana ICT for Accelerated Development (2003) policy underlines the need to "encourage R&D activities aimed at the development of tools, equipment and machinery for

industries, and encourage quality assurance in manufacturing; support biomedical research and improvement in the general health delivery system, and promote research into plant medicine to complement allopathic medicine" (ICT4AD, 2003, p.66); "set up national-level institutional framework[s] and structures for taking process development at academic institutions and R&D laboratories closer to industrial acceptance" (ICT4AD, 2003, p.67).

## 8.3 Policy Review on Science, Technology and ICT

Capabilities in STI are significant determinants of progress and transition to knowledge sharing and diffusion to facilitate new innovations that enhance productivity increases. STI represent powerful tools for developmental policies to utilise key resources for economic growth, particularly the use of scientific and technological knowledge and their related institutional externalities. The GNSI Survey seeks to address the almost non-existent, evidence-based measures for guiding policy prescriptions concerning STI, and the structural relationships between, and within, Government, Industry, KBIs and Arbitrageurs. This will assist in meeting the objectives of Ghana's medium-term development policy framework as contained in the Ghana Shared Growth & Development Agenda 2010-2013.

Over the years, there has been a consensus by the Government to restructure STI, aiming to address specific developmental challenges. The National STI Policy pays attention to building a "strong STI capacity to support the social and economic developmental needs of a middle-income country" (National STI Policy, 2010, p.2-16).

The basic objectives of the National STI Policy are to: facilitate mastering of scientific and technological capabilities by a critical mass of the graduates from all institutions; provide the framework for inter-institutional efforts in developing STI programmes in all sectors of the economy; create the conditions for the improvement of scientific and technological infrastructure for R&D and innovation; ensure that STI supports Ghana's trade and export for greater competitiveness; and promote a science and technology culture. The National STI Policy highlights the core activities and programmes required in the different sector ministries, departments and agencies to develop knowledge and skills by applying STI. Well-educated and highly trained scientists and technologists with specific knowledge and skills will be required to provide particular services to enable all sectors to discharge their vision, mission and strategies.

Ghana intends to contextualise the National STI Policy and integrate it fully into a national development strategy which gears the nation's Science and Technology to "achieve national objectives for wealth creation, poverty reduction, competitiveness of enterprises, sustainable environmental management and industrial growth" (National STI Policy, 2010, p.16). The National STI Development Programme of Ghana (STIDEP I, 2010) is to provide a framework for coordinating and directing the implementation of the National STI Policy, wherein its specific objectives include: to identify priority programmes and projects to implement the strategies designed to achieve the medium-term objectives of the National STI Policy; to provide an indicative budget for implementing the identified programmes and projects; to provide a monitoring and evaluating system that will ensure effective management of the implementation for the required results[11].

The Ghana ICT for Accelerated Development Policy (2003) represents the vision for Ghana in the information age. The development of the policy framework is based on a nation-wide consultative process involving all key stakeholders in the public and private sectors and civil societies. This policy is designed to assist Ghana's development process by addressing the nation's key developmental challenges such as under-developed physical communications infrastructure and limited human resource skills capacity in general, and in ICT in particular, characterised by the low professional, technical and managerial manpower-base available nationally (ICT4AD, 2003, p.6). However, it has been acknowledged that for Ghana to move its relatively weak industrial economy towards an information- and knowledge-driven economy, it will need to develop and implement comprehensive integrated ICT-led, socio-economic development policies, strategies and plans.

In relation to civil and public services, the deployment and exploitation of ICT is a cardinal support to the operations and activities of the public sector. Thus, the aim of the Ghana ICT for Accelerated Development Policy (2003) is to engineer an ICT-led, socio-economic development process, which has the potential of transforming Ghana into a middle-income, "information-rich, knowledge-based and technology-driven economy" (ICT4AD, 2003, p.25). The policy seeks to improve the efficiency and effectiveness of management in the discharge of the administrative functions of public Ministries and their missions abroad through the deployment and exploitation of ICT.

Since 2000, Ghana has adopted the targets of the Millennium Development Goals (MDGs) as the minimum requirements for socio-economic development and poverty reduction. The GoG aims to orient the nature of the country's economy towards productivity enhancing growth and, therefore, to increase wealth and welfare; enable accelerated poverty reduction; enhance protection of the vulnerable and create a sound democratic environment. The Ghana Poverty Reduction Strategy I (2003-2005) and the Ghana Poverty Reduction Strategy II (2006-2009) are focused on the need for a robust development of Science and Technology to bolster industrial production, employment, and natural resource development, food and security, sustainability and environmental health. The policy objective under Science and Technology is to

[11] The longitudinal repetition of the GNSI survey methodology and data acquisition instrument is one key element in such a monitoring and evaluating system to enable effective management of innovation policy.

promote the adoption of appropriate technologies, both local and foreign, with the capacity to improve productivity and efficiency in the agricultural and industrial sectors especially for small and medium-scale rural enterprises. In the area of crop production in particular, there is the need to intensify research-extension officer-farmer linkages to ensure that technologies are developed and disseminated appropriately to meet world-wide market standards. Funding should be made available to farmers to work with higher educational institutions, industry and research institutes to help improve productivity in the agriculture sector.

As part of the promotion of STI and ICT capacity in the country, the NSI offers a crucially important strategic path in creating linkages and knowledge sharing in order to facilitate R&D in and among key institutions in Ghana. To enhance the development of NSI, there is a need for coordination of STI activities among the key Actors of the economy (Government, KBIs, Industry, Arbitrageurs). The National STI Policy identifies Government as the major driver in achieving the aims of development through enhancing the NSI. The aims and objectives of the National STI Policy are directed towards coordinating with the other key Actors in the NSI development. In line with the National STI Policy, the Government has the "vision for science and technology-led economic growth" (National STI Policy, 2010, pp.4-34). The success of integrating STI into the country's development agenda depends on the establishment of appropriate instruments for financing the STI development.

### 8.3.1 Policy Strategies and Incentives

The National STI Policy aims to promote a culture of STI through public and private awareness campaigns, and the development of an information system to enhance the scientific thinking of Ghanaians in their everyday lives. Strategies and incentives in achieving this include to: facilitate the packaging of research findings to be disseminated by the mass media; facilitate the training of human resources in STI writing and communication; popularise STI through the establishment, investment and management of science museums, STI fairs and exhibitions to allow public participation in STI activities in all parts of the country" (National STI Policy, 2010, pp.3-27); and, to give "deserving scientists, engineers and technologists special recognitions through awards" (National STI Policy, 2010, pp.4-35).

With regard to KBIs, "public research institutes should view themselves as 'technological service providers' whose mission is to support local firms, farmers, and other economic actors for the development of their local economies" (UNCTAD, 2011, p.14). More investments in KBIs and incentive structures would be required to achieve this.

Strategies in the National STI policy are to: "promote post-graduate education in scientific disciplines targeting 10% of the student population in tertiary educational institutions enrolling at the post-graduate level"; [...] promote Science and Technology innovativeness within the educational system and create special incentives for students and graduates of Science and Technology; [...] enhance collaboration between research institutions and universities to train high-level scientific manpower" (National STI Policy, 2010, pp.2-23).

The National STI Policy aims to promote the use of ICT to ensure that modern ICT are available and utilised at all levels of society. Specific ICT strategies include: "to ensure STI capabilities exist to integrate ICT into all sectors of the economy including education, industry, agriculture and health; [to] develop a national competence for computer hardware and software engineering and information security; [and to] facilitate the development of a modern ICT infrastructure to improve teaching, learning and research" (National STI Policy, 2010, pp.3-27).

In view of the GoG efforts to provide funds to meet the demands of STI, the strategies and incentives that are being implemented include: to "take stock of all existing funding lines established to support the development of science and technology in industry with the aim of streamlining them to achieve economies of scale in their operations"; to "encourage the private sector to support the funding for R&D activities, especially to cater for the needs of the micro, small and medium enterprises (MSMEs), which can be nurtured for the commercialization of novel products or processes (that is, products of innovation)". Furthermore, it aims to "accelerate the allocation of a minimum of 1% of the Gross Domestic Product (GDP) to support the science and technology sector; [and to] institute attractive tax incentive mechanisms for contributors to the instituted funds or directly to R&D activities in such a way as not to erode the national tax base" (National STI Policy 2010, pp.5-37) of the economy.

Moreover, to encourage venture capital investments in private and public sector development, the National STI Policy has strategised the creation of a venture capital fund administering authority. The fund authority has the sole purpose of harnessing the "commercialization of new technologies from scientific and technological institutions" (National STI Policy 2010, pp.5-37) to encourage public and private procurement of products and services from Science and Technology institutions.

To obtain maximum and effective outputs from the strategies and incentives, the GoG has pledged to "solicit the effective participation and contribution of the private sector as an indispensable partner in the management of science and technology for the commensurate benefit of knowledge sharing to enhance the socio-economic development of the country" (National STI Policy 2010, pp.5-38).

## 8.4 Policy Review on Education

Education is one of the most important areas in the development of the NSI. Education is a key factor to create a knowledge-based economy. Hence, to competitively

participate in the global economy, the Ghana economy needs an educated and skilled labour force and it must create, share and use knowledge (Obeng, 2004). This section provides a contextual analysis of Ghana's policy documents on STI within the educational sector. In this context, the aim stated by the GoG is "to transform Ghana into a middle income, information-rich, knowledge-based and technology driven economy and society" (ICT4AD, 2003, p.8).

The Preliminary Education Sector Report (2008) recognises that the country lacks "strategic forward planning to promote Science and Technology as a vehicle for economic development". It also underlines that conscious efforts to enhance scientific and technological education is missing and that "Science and Technology education is not responding adequately to development needs due to inadequate funding, poor management and obsolete pedagogical strategies. [...] Industries in Ghana are not adequately involved in the programmes developed in the Tertiary Institutions creating a gap in the programmes offered in the institutions and the needs of industry" (The Preliminary Education Sector Report, 2008, p.155).

The Education Strategic Plan I 2003-2015, introduced to address the quality of education in the country, identifies four key areas of focus (Equitable Access to Education, Quality of Education, Educational Management and Science, Technology and Technical Vocational Education Training (TVET)). The current sector policy, the Education Strategic Plan 2010-2020, aims to improve the quality of learning and teaching, to modernise and extend ICT, science education, technical and vocational education and training, and to enhance skills development at all levels.

The GoG has placed emphasis on the role of ICT in the education field in contributing to the country's economy. The objective is to promote ICT in schools and institutions of higher learning. The Ghana ICT for Accelerated Development Policy (2003) represents the vision of Ghana to promote ICT in education, develop and spread ICT in the country and develop scientific and industrial research capacity by exploiting the advantages of ICT (ICT4AD, 2003).

According to the Education Strategic Plan II 2010-2020, Ghana's public R&D institutions and higher educational institutions have weak linkages and limited interactions. The policy also highlights the lack of consultation with private sector Actors, particularly industry, especially with respect to identifying areas for R&D. It also recognises the need to develop processes and strategies for research funding, and ensure that R&D findings are relevant to national development (Education Strategic Plan II, 2010).

In the context of the NSI, there is the need for effective coordination among Government, KBIs, Industry and Arbitrageurs, in order to enhance competitiveness and innovation in the Ghanaian economy. The focus on these key Actors is based on the fact that they possess knowledge and are directly involved in policy-making that impacts the country's productivity and competitiveness. The Government is a major stakeholder, and its policy objectives and plans are carried out through the Ministry of Education. In addition, it has an advisory committee known as the Education Sector Technical Advisory Committee (ESTAC), which has the overall responsibility of advising and following through on the proposals in the plan (ESP I, 2003). KBIs play a crucial role, and efforts will be made to encourage "all actors in promoting applications of information and communication technology (ICT) to daily activities, whether at a personal level or in the workplace" (ESP I, 2003, p.15). Industries rely mostly on the educational sector to provide them with skilled personnel. In terms of intermediation, the GoG is the predominant source of education funding mostly through local sources like the GoG fund, the Ghana Education Trust fund and internally generated funds. Additionally, external sources like the Heavily Indebted Poor Countries (HIPC) monies and donors are also included (ESP I, 2010, p.40).

### 8.4.1 Policy Strategies and Incentives

Science and Technology in education strategies are to: design a national Science and Technology policy; and revitalise laboratories and workshops and increase investment in science and technology (ESP I, 2003). Furthermore, the Education Strategic Plan I 2010-2020 targeted the mainstreaming of mathematics, science and technical education at all levels, as well as the extension and the diversification of post-graduate programmes, especially in the applied sciences. In addition, the STI Policy, in its short-term objectives, places emphasis on revitalising the teaching of science at basic, secondary and tertiary levels of the education system.

The Education Strategic Plan I 2010-2020 policy further outlined strategies regarding the promotion of ICT in education, namely by providing relevant opportunities for ICT and skills development, and ensuring that science and computing students have access to relevant up-to-date teaching/ learning materials. In achieving the goals of ICT in education policy, the objectives and the strategies are outlined in three phases. Phase I aims to enhance a system-wide and institutional readiness to use ICT for teaching, learning and administration, (teachers' capacity building in ICT). Phase II has the intent to ensure a system-wide effective integration of ICT into teaching and learning. Phase III intends to integrate ICT at all levels of the education system, namely, management, teaching, learning and administration. The Government has also underlined the need to promote "collaboration between local and international educational institutions to facilitate educational exchange and the promotion of ICT education and training" (ICT4AD, 2003, p.39).

The Education Strategic Plan II 2010-2020 has the objective of strengthening linkages between tertiary education and industry. Different strategies are identified, namely: the integration of "entrepreneurial training and career counselling

into academic programmes in all tertiary institutions"; the promotion of "programmes and research activities of national development in collaboration with the private sector"; while the publication of research to demonstrate relevance for national development would "enhance the use of electronic libraries and the storage and publication of research papers and findings" (ESP II, 2010, pp.41-42).

It is clear, from the text of the various policies documenting the GoG strategic posture toward the widespread application of STI through the NSI in the economy that the GoG recognises the importance of technology-driven industrialisation. It is also apparent that the quantification of policy incentives, instruments and regulation to achieve policy objectives is seriously truncated – with the exception of the National STI Policy (2010) indication of allocating a minimum of 1% of GDP to support Science and Technology[12].

The understandable plethora of neither quantified, nor indexed, policy directives, recommendations and incentives in the policy documents, renders policy management difficult at best, and nigh on impossible at worst, in terms of coordination, sequential prioritisation, operationalisation and control. The policy prescriptions echelon is not immediately visible in the inter-ministerial articulation of policy strategies and incentives performance (regulatory, fiscal and monetary).

Notwithstanding the evolution of policy craft, resource application[13] is also rendered problematic by a general absence of quantified or indexed policy directives linking desired outputs with inputs.

The policy analysis, and policy recommendations, provided by the GNSI are intended to address these shortcomings in part by measuring the linkages within, and between, the key policy Actors.

[12] It should be noted that, in terms of strategic business plans and management actions for policy implementation, one cannot manage what is not measured; what is important gets measured; and what gets measured gets done because of the consequences of performance appraisal and sub-sequential adjustment.

[13] That is the level, rate and hierarchy of resources to be applied to realise policy objectives.

# 9.0 Policy Analysis, Implications and Recommendations

## 9.1 Preamble

The overall assessment and conclusions from the GNSI Survey are, at first sight, not encouraging. The GNSI is hallmarked by: (i) very weak, truncated, perforated and absent linkages within, and between, Actors; (ii) very high barriers to innovativeness, and very high constraints on innovation; and, (iii) largely unsuccessful policy instruments in promoting innovativeness and innovation in the national economy.

However, this overall poor scorecard must be viewed through the lens of Sub-Saharan Africa's generally unprecedented improvements, and Ghana's recent economic performance in particular.

In 2000, Africa was labelled "the hopeless continent" (The Economist, 13 May 2000). In 2011, The Economist labelled Africa "the hopeful continent" (The Economist, 3 Dec. 2011), indicating, along with the World Bank, that since 2000, "six of the world's ten fastest-growing countries were African. In eight of the past ten years, Africa has grown faster than East Asia, including Japan" (The Economist, 3 Dec. 2011). Ghana is expected to attain most of the MDGs "if not by 2015 then soon thereafter" (World Bank, 2011, p.3).

The transformation has resulted in Africa's trade with the rest of the world increasing by 200% since 2000, with inflation declining from 22% (1990s) to 8% (2000s), and growth forecasts that average 5.75% in 2012. For Ghana, the GDP growth forecasts range between 11.5% to 16.7%[14], and Ghana attained middle-income country status in November 2010 (Moss and Majerowicz, 2012)[15]. According to the World Bank (2011) there are five fundamental reasons responsible for this transformation across Africa and Ghana. First, average growth rates of about 5% since 2000, and over 6% between 2006 and 2008. Second, significant progress on the MDGs. Third, the increasingly attractive investment prospects in Africa's private sector. Fourth, the returns from market-oriented reforms. Fifth, in Ghana's case, its newly acquired status as an oil producer and exporter (expected to propel GDP growth in 2012-2013 to between 8% and 9%).

Given such a perspective, the results from the UNIDO GNSI Survey portend policy advantages that can enable the GoG to achieve its policy objectives regarding innovativeness and innovation.

[14] www.howwemadeitinafrica.com, "Ghana economy expected to grow by 13.5% this year", 13/August/2011

[15] This is qualified by its lower middle-income at US$1,363 GDP per capita, eligibility by the International Development Association (IDA) and "a somewhat unconventional and in many ways unexpected way a technical statistical adjustment" (Moss and Majerowicz, 2012, p.1).

## 9.2 Characteristics of GNSI Survey (Sample and Respondents)

The UNIDO GNSI Survey is based on the GoG Policy articulation of national priorities with respect to enabling the application of higher levels of innovation throughout the economy. It is the first of its kind, in that it maps and measures the NSI – that is the inter- and intra- relationships (institutional linkages, policy proximity, convergence or divergence, and connectedness) between policy decision-makers at the highest level in Government (GOV), Medium and High-Technology Industry (MHTI), Knowledge-Based Institutions (KBIs), and Arbitrageurs (ARBs), (comprising Financial Institutions (FIs), Venture Capitalists/Knowledge Brokers), respectively[16]– as opposed to carrying out solely a survey of innovation in companies or a review of STI limited to indicators and policy[17]. With this in mind, it should be noted that the 2009 report, The Ghana Innovation Survey by the Science and Technology Policy Research Institute (STEPRI), August 2010, surveyed 200[18] organisations and obtained 116 responses from firms or enterprises.

The following nomenclature is used texturally with respect to Actors in the GNSI:

| GNSI Actor | Abbreviation |
|---|---|
| All Actors | ALL |
| Government | GOV |
| Institutions Supporting Technical Change | ISTC |
| Medium- and High- Technology Industry | MHTI |
| Business Enterprises | BE(s) |
| Knowledge-Based Institutions | KBI(s) |
| Higher Education | HE |
| Research Institutions | RI(s) |
| Arbitrageurs | ARB(s) |
| Financial Institutions | FI(s) |

[16] From here on in Actors will referred to by their abbreviation when appropriate, with respect to ease of readability.

[17] STEPRI (Science and Technology Policy Research Institute), 2010. *The Ghana Innovation Survey Report 2009*. Accra: CSIR-STEPRI; UNCTAD (United Nations Conference on Trade and Development), 2011. *Science, Technology and Innovation Policy Review*. UNCTAD/DTL/STICT/2009/8. Geneva: United Nations.

[18] "The sample size was 200 consisting of 120 business enterprises, 38 government institutions/organizations, and 27 higher education (tertiary) institutions." STEPRI August 2010.

It is important to portray the characteristics of the survey in terms of the universal population, convenient sample and Respondents. Table 9.1 below indicates the size of the universal population of the four Actors targeted in the GNSI Survey.

***Table 9.1** – GNSI Universe and Convenient Sample of Respondents*

| Actors | Universe of Respondents | Convenient Sample (Accessible Potential Respondents) | (%) Percentage of Universe of Respondents |
|---|---|---|---|
| Government[19] | 260 | 166 | 63.85 |
| MHT Industry[20] | 120 | 87 | 70.83 |
| Knowledge-Based Institutions[21] | 182 | 175 | 96.15 |
| Arbitrageurs[22] | 16 | 16 | 100 |
| Totals | 578 | 444 | 76.82 |

The UNIDO GNSI Survey obtained valid and reliable responses as shown in Table 9.2 – below, indicates the percentage response rate per Actor.

***Table 9.2** – Distribution of GNSI Survey Returns by Actor*[23]

| Actor | Convenient Sample | Responses | Response Rate (%) |
|---|---|---|---|
| Government Policy-Makers | 166 | 39 | 33.6 |
| MHT Industry | 87 | 60 | 68.9 |
| Knowledge-Based Institutions | 175 | 129 | 73.3 |
| Arbitrageurs (Venture Capitalists/ Knowledge Brokers) | 16 | 6 | 37.5 |
| All Actors | 444 | 234 | 52.7[23] |

First, the executive policy community essentially the Government (GOV) is represented by high-level officials in the relevant public institutions directly or indirectly responsible for innovation. These include the Ministries of Trade and Industry, Science and Technology, Economy, Finance, Education[24].

Second, the knowledge community in terms of Knowledge–Based Institutions (KBIs) is represented by heads of universities and innovation-related faculties/departments (economics, science, engineering, technology and business) in Higher Education (HE), as well as heads of think-tanks and Research Institutes (RIs). Additionally, privately funded Research Institutes are also considered in this category[25].

Third, the industrial community is represented by the Chief Executive Officers (CEOs) of firms in the Medium- and High-Technology (MHTI) manufacturing sector in accordance with the UNIDO ISIC Rev. 3 classification.

Finally, the intermediary body selected was Arbitrageurs (comprising Financial Institutions (FI), Venture Capitalists and Knowledge Brokers). This group of Actors is not represented in the traditional Triple Helix model, but is of crucial importance as the innovation process requires internal and external knowledge intermediation (financial, transacting and investment), which has led to new business models and new types of companies in countries with advanced innovation-driven economies.

As such, Arbitrageurs complement the traditional Triple Helix model by the provision of funds, links, knowledge sources and even technical knowledge. This enables firms to improve their performance and survival rates, as well as to accelerate and increase the effectiveness of their innovation processes (Zook, 2003; Hargadon, 1998; Baygan and Freudenberg, 2000). The combined intermediation and resource allocation role of Arbitrageurs is based on their assessment of competitive advantages in information asymmetries (Williamson 1969, 1971, 1973).

The maps and tables that follow provide a spatial analysis of the GNSI Actor Respondents in terms of location density (the universe, convenient sample, responses). The universe is in effect a 'Who is Who and Where' in innovation in Ghana[26]. It is the first comprehensive database of policy-makers in GOV, KBI, MHTI and ARB, dealing with innovation. The universal database constitutes the first of several public goods outcomes from the GNSI Survey. As a key dimension of the effectiveness and efficiency of a NSI is proximity in terms of connectedness and linkages, it is crucial to appreciate the spatiality of GNSI Actors, as it has implications for policy design.

[19] Leadership in government (Minister, Deputy Minister and Chief Director) policy making.

[20] High level management in Medium-High-Technology Industry (MHTI)-(Chief Executive Officers).

[21] Leadership in Knowledge-Based Institutions (KBI) (faculty deans and departmental heads).

[22] Chief Executive Officers.

[23] In surveys directed towards senior management the general response rate is at 30%. See Harzing, A.W., 2006. Response Styles in Cross-National Survey Research. A 26-country Study. *The International Journal of Cross Cultural Management*, 6(2), pp. 243-266.

[24] See Annex II- for full list of Government Ministries.

[25] See Annex III- for full list of KBIs.

[26] Due to the innovativeness of the UNIDO methodology we have names, affiliation, and contact details of the universe of Actors. This database can be used for policy monitoring and evaluation purposes with respect to mobility of human capital between, and within, GNSI Actors (which increases the flows of knowledge within the system).

With the exception of KBI and GOV Actor Respondents, MHTI and ARB are concentrated in the south-east parabolic Ashanti-Eastern-Greater Accra (Super) region. ARB are specifically concentrated in the capital Accra. KBI are distributed along and around the right of north-south axis of the country. The spatiality and distribution of Actors carries implications in terms of the policy recommendations. Without pre-empting such recommendations, it is clear that with respect to ICT access connecting KBIs in the Northern, Ashanti, Eastern, Central and Greater Accra Regions, is a must in terms of broadband Internet access. Figure 9.1 indicates the distribution of Actors. Tables 9.3 – GNSI Actor by Region (Universe), 9.4 – GNSI Actor by Region (Convenient Sample), – and 9.5 – GNSI Actor by Region (Responses) – below show the exact percentages.

***Figure 9.1*** *– Spatial Analysis of GNSI Actors' Universe, Convenient Sample and Respondents*

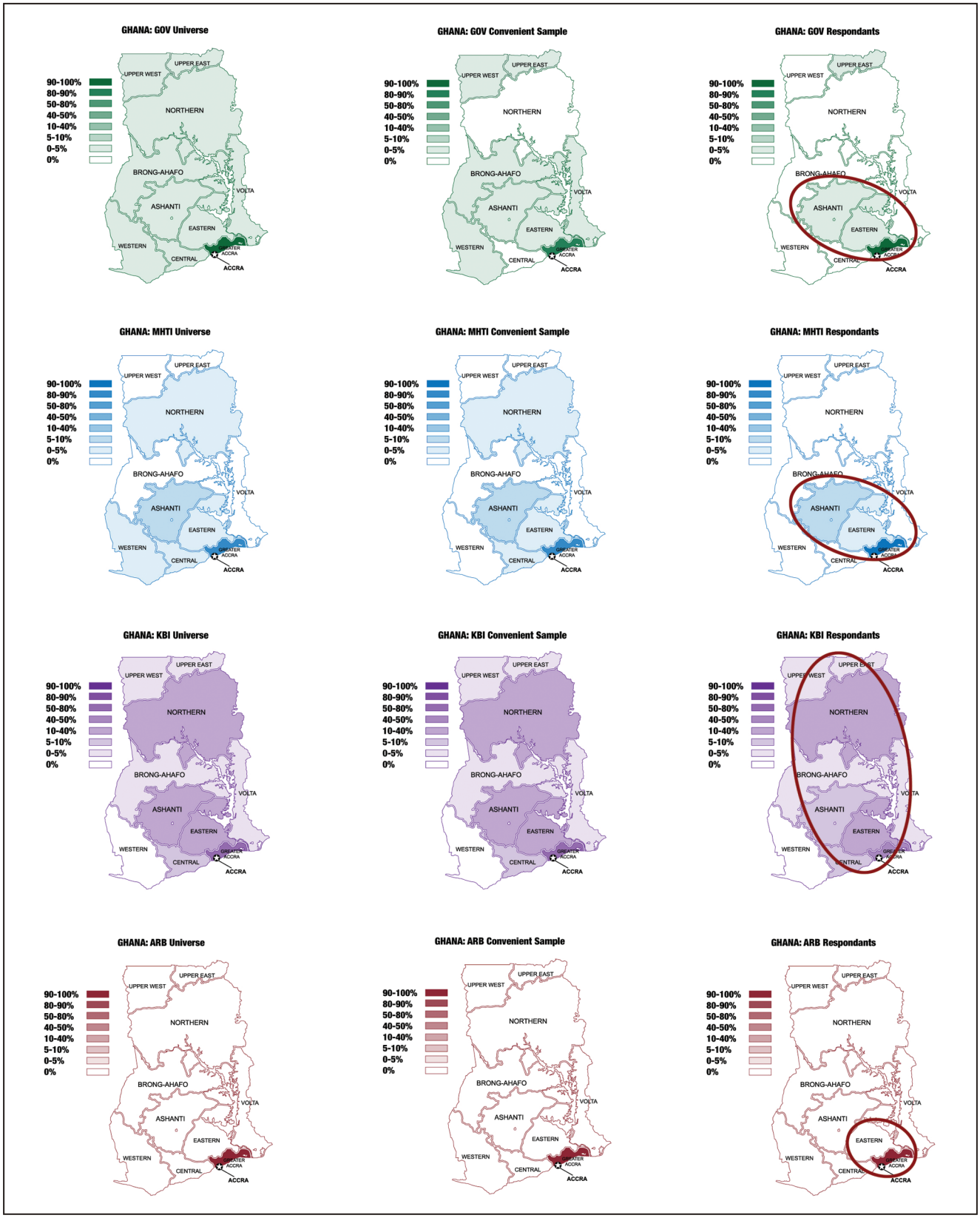


***Table 9.3** – GNSI Actor by Region (Universe)*

| Universe | GOV | GOV % | MHTI | MHTI % | KBI | KBI % | ARB | ARB % |
|---|---|---|---|---|---|---|---|---|
| Upper East | 2 | 0.76 | 0 | 0.0 | 5 | 2.74 | 0 | 0.0 |
| Upper West | 2 | 0.76 | 0 | 0.0 | 4 | 2.19 | 0 | 0.0 |
| Northern | 2 | 0.76 | 2 | 1.66 | 20 | 10.98 | 0 | 0.0 |
| Brong-Ahafo | 2 | 0.76 | 0 | 0.0 | 4 | 2.19 | 0 | 0.0 |
| Ashanti Land | 2 | 0.76 | 7 | 5.83 | 20 | 10.98 | 0 | 0.0 |
| Western | 5 | 2.08 | 1 | 0.83 | 0 | 0.0 | 0 | 0.0 |
| Eastern | 2 | 0.76 | 2 | 1.66 | 20 | 10.98 | 0 | 0.0 |
| Central | 1 | 0.38 | 1 | 0.83 | 14 | 7.69 | 0 | 0.0 |
| Greater Accra | 240 | 92.3 | 107 | 89.16 | 93 | 51.09 | 16 | 100.0 |
| Volta | 2 | 0.76 | 0 | 0.0 | 2 | 1.09 | 0 | 0.0 |
| Total | 260 | - | 120 | - | 182 | - | 16 | - |
| Total of Totals | 578 | | | | | | | |

***Table 9.4** – GNSI Actor by Region (Convenient Sample)*

| Convenient Sample | GOV | GOV % | MHTI | MHTI % | KBI | KBI % | ARB | ARB % |
|---|---|---|---|---|---|---|---|---|
| Upper East | 2 | 1.25 | 0 | 0.0 | 5 | 2.85 | 0 | 0.0 |
| Upper West | 2 | 1.25 | 0 | 0.0 | 4 | 2.28 | 0 | 0.0 |
| Northern | 0 | 0.0 | 1 | 1.15 | 19 | 10.85 | 0 | 0.0 |
| Brong-Ahafo | 2 | 1.25 | 0 | 0.0 | 4 | 2.28 | 0 | 0.0 |
| Ashanti Land | 2 | 1.25 | 5 | 5.74 | 18 | 10.28 | 0 | 0.0 |
| Western | 5 | 3.36 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| Eastern | 2 | 1.25 | 2 | 2.3 | 20 | 11.42 | 0 | 0.0 |
| Central | 0 | 0.0 | 1 | 1.15 | 13 | 7.42 | 0 | 0.0 |
| Greater Accra | 149 | 89.76 | 78 | 89.66 | 90 | 51.42 | 16 | 100.0 |
| Volta | 2 | 1.25 | 0 | 0.0 | 2 | 1.14 | 0 | 0.0 |
| Total | 166 | - | 87 | - | 175 | - | 16 | - |
| Total of Totals | 444 | | | | | | | |

***Table 9.5** – GNSI Actor by Region (Responses)*

| Respondents | GOV | GOV % | MHTI | MHTI % | KBI | KBI % | ARB | ARB % |
|---|---|---|---|---|---|---|---|---|
| Upper East | 1 | 2.56 | 0 | 0.0 | 4 | 3.1 | 0 | 0.0 |
| Upper West | 0 | 0.0 | 0 | 0.0 | 4 | 3.1 | 0 | 0.0 |
| Northern | 0 | 0.0 | 0 | 0.0 | 17 | 13.18 | 0 | 0.0 |
| Brong-Ahafo | 0 | 0.0 | 0 | 0.0 | 4 | 3.1 | 0 | 0.0 |
| Ashanti Land | 1 | 2.56 | 4 | 6.67 | 12 | 9.3 | 0 | 0.0 |
| Western | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| Eastern | 1 | 2.56 | 2 | 3.33 | 14 | 10.85 | 0 | 0.0 |
| Central | 0 | 0.0 | 0 | 0.0 | 10 | 7.75 | 0 | 0.0 |
| Greater Accra | 36 | 92.3 | 54 | 90.0 | 62 | 48.06 | 6 | 100.0 |
| Volta | 0 | 0.0 | 0 | 0.0 | 2 | 1.55 | 0 | 0.0 |
| Total | 39 | - | 60 | - | 129 | - | 6 | - |
| Total of Totals | 234 | | | | | | | |

## 9.3 Characteristics of GNSI Survey Analysis

The GNSI Survey obtained quantitative data on five dimensions of the NSI, namely

Constitution of the NSI
Components of the NSI
Barriers to Innovation
Policy Processes
Measuring Innovative Performance

Actor perceptions of NSI variables in these dimensions were measured by enabling Respondents to express both the direction and strength of their expert opinion (Garland, 1991; Clason and Dormody, 1994) along five point Likert scales, as well as in dichotomous, trichotomous and open questions. There is strong empirical evidence that supports the treatment of ordinal variables as conforming to interval scales (Labovitz 1967, 1970, 1971). In order to ensure the highest validity and reliability of the acquired data, the GNSI Survey instrument used test–retest questions (Easterby-Smith, et al., 2012). With respect to test-retest (Intra-observer) reliability, this was achieved by repeating certain questions under different dimensions of the survey. This is the basis of test-retest reliability (Kitchenham and Pfieeger, 2002), which allows consistency and significance of responses by Respondents to be validated through statistical analysis.

Not all variables analysed are reported. A selection of variables relevant to Actor importance and linkages (inter/intra); level of innovativeness; barriers to innovation and policy instrument success; underlying factors to barriers to innovation; policy instruments and success; and underlying factors to policy success are reported. These findings are central to policy recommendations and hence the effectiveness and efficiency of the GNSI within the national economy.

The analytical results are based on cross-tabulations and factor analysis which are reported at a statistically significant confidence level of 95% or above. This is of crucial importance when it comes to policy implications arising from the analysis and hence policy recommendations arising from these policy implications. Such significance provides high levels of confidence in the results and the meaningfulness of the results with respect to robust policy craft. It is important to note that the vast majority of surveys on innovation report, as the principle source of analytical information, statistics based solely on frequencies[27].

Cross-tabulation represents a unique combination of specific values of variables. Thus, cross-tabulation allows the examination of statistically significant observations and relationships (in this case, the inter- intra-linkages between GNSI Actors, and NSI variables). By examining these observations, we can identify systematic relationships between variables through the Chi-square test of significance. This enables us to report results of relationships that are statistically significant and robust. The figures reported, in percentage terms, are imbued with a statistically significant Chi-square value at the confidence level of 95% or above. In other words, the Chi-square analysis indicates the high level of probability that the GNSI Survey finds evidence in support of systematic relationships between the variables and when repeated would produce the same result[28]. Additionally, when repeated longitudinally, similar systemic relationship between variables (albeit with changing values) would be found. Thus, if the Chi-square probability value is less than or equal to 0.05, there is a significant systematic relationship between the NSI variables examined.

Factor analysis reduces observed variables into factors within a pattern matrix (clusters of inter-correlated variables) with 'mutual interdependence' (Gaur, 1997). The factors represent the underlying structure responsible for the variation of variables in the data, sample and hence the population and universe of Respondents (Kim and Mueller, 1978). The goal of factor analysis is to represent parsimoniously statistically significant relationships among sets of variables while keeping factors meaningful. The statistically significant confidence level in factor analysis is represented by the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy. The KMO value indicates the quality of the common factors. A KMO value of 1 represents perfect sampling adequacy. KMO values >0.9 represents "marvelous" sampling adequacy; >0.8 <0.9 represents "meritorious" sampling adequacy; >0.7 <0.8 represents "middling" sampling adequacy; >0.6 <0.7 represents "mediocre" sampling adequacy; >0.5 <0.6 represents "miserable" sampling adequacy; and <0.5 represents "unacceptable" sampling adequacy (Kim and Mueller 1978). In addition, the Bartlett's Test of Sphericity (BTS) significances indicate reproducible and generalisable results of the factor analysis from the sample and hence the GNSI (Kim and Mueller, 1978, p.54; Kaiser, 1974; Dziuban and Shirkey, 1974, p.359; Rummel, 1970).

## 9.4 Characteristics of GNSI Survey Results

In reporting the GNSI survey results with respect to the cross-tabulations of Likert scale measured variables, the five point Likert scales are dichotomised into the limits of the measurement scale of the statistically significant variables as follows:

- Very Important – Irrelevant (VI-I);
- Very Strong – Very Weak (VS-VW);
- Very Positive – Very Negative (VP-VN);
- Very Strongly – Very Weakly (VS-VW);
- Very High Innovativeness – Very Low Innovativeness (VHI-VLI);
- Very Highly Successful – Not Successful (VHS-NS);
- Very High Constraint – Very Low Constraint (VHC-VLC).

Neutral was assigned to the Irrelevant, Very Weak, Very Negative, Very Weakly, Very Low Innovativeness, Not Successful, and Very High Constraint categories, respectively, on the basis that a neutral perception given by an expert Respondent, from the perspective of policy implications and policy recommendations, is not positive. This conservative choice of dichotomisation, or condensation, enables policy implications to be assigned to the policy analysis of the results and permits robust policy recommendations to be made with confidence.

From the GNSI survey instrument selected variables were paired in the cross-tabulations. This provides a mapping of the statistically significant combinatorial measures (at the limits of the scale) of the relationships between the selected variables.

[27] Statistically significant confidence levels cannot be ascribed to ordinary frequencies.

[28] This is the purpose of such instrumentation in evidence-based policy making and the use of the DASI longitudinally for policy assessment, monitoring and adjustment.

In order to orient policy-makers towards the implications, and hence recommendations, the analysis focuses on deficiencies, as well as proficiencies, in the GNSI. The purpose is that available resources (fiscal, monetary, regulatory, performance), which may be applied, can be effectively directed and targeted to strengthen the relevant proficiencies and address deficiencies as a matter of choice and in an order of priority.

With respect to the factor analysis, the factor names were assigned on the basis of the factor loading of the variables associated with each factor, taking the higher loadings into consideration. The naming of factors therefore reflects the variables that are most influenced by the underlying factor. The naming of factors is crucial to a meaningful discussion on policy, and the reporting relies on an understanding of the national environment of STI in Ghana that emerges from qualitative analysis of policy documents as indicated in Chapter 8 above, as well as a judicious use of the international empirical evidence and theory of NSI[29].

## 9.5 Results of the GNSI Survey

Not all variables of the GNSI analysed are reported. As previously mentioned, a selection of variables relevant to Actor importance and linkages (inter/intra); level of innovativeness; barriers to innovation and policy instrument success; underlying factors to barriers to innovation; policy instruments and success; and, underlying factors to policy success are analysed and reported.

It is important to re-emphasise that the results presented are from an analysis of the National System of Innovation (NSI), with respect to the system's internal relationships between, and within, principal Actors. The results are therefore a view of the system's structure and behaviour, and hence its efficiency in parts and effectiveness as a whole. The OECD (1999) points out that the overall efficacy of the NSI is increasingly reliant on the science base, networking and collaboration.

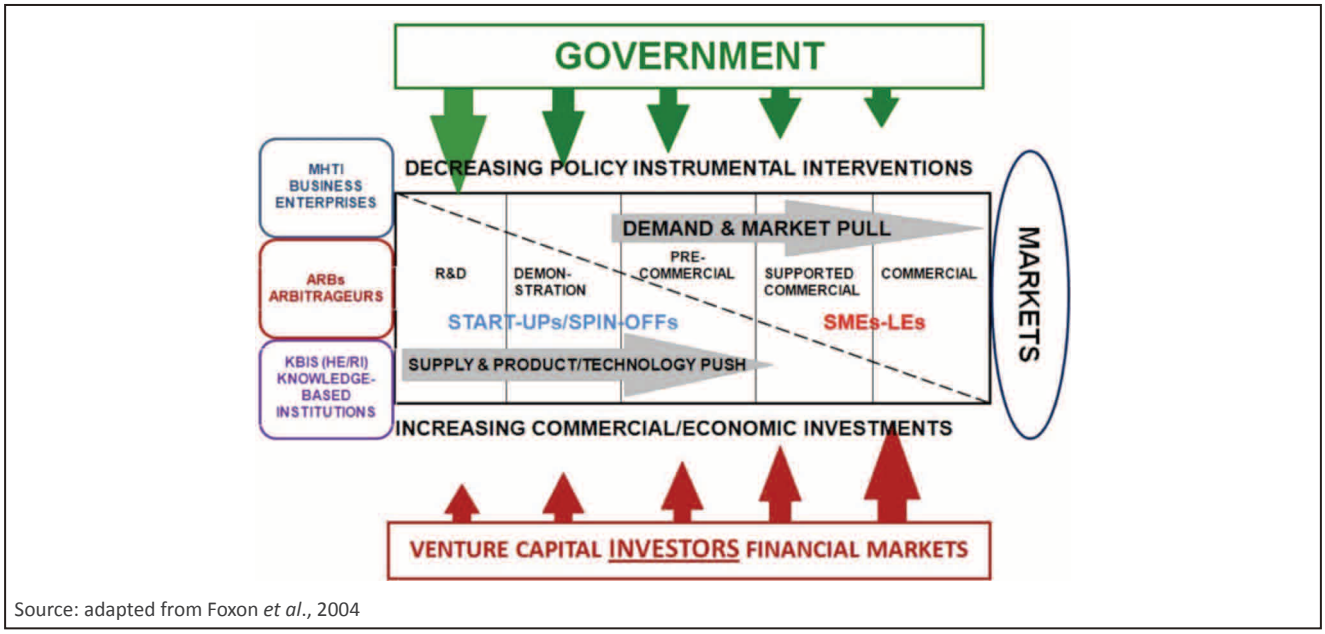
The selected variables that are analysed and reported are specifically:

- Research Institution (RI) linkages with the production system and level of innovativeness of Business Enterprises (BEs);
- Actor importance and strength of inter-, intra-Actor linkages;
- Strength of inter-, intra-Actor linkages and level of innovativeness of Business Enterprises (BEs);
- Factor constraints on innovation;
- Success of policy instruments in promoting innovation and factor constraints on innovation;
- Policy instruments available and success of policy instruments in promoting innovation; and
- Underlying factors of success of policy instruments in promoting innovation.

In this reporting of the GNSI Survey, the focus is on policy analysis arising from the results, policy implications arising from the policy analysis, and policy recommendations which emerge from the policy implications.

First, the policy recommendations are action oriented and require an implementation schedule that is long-term and realistic, and which commands the consensus of policy-makers. Such a long-term perspective should be seen in terms of decades. The framework – Policy Stages in the Dynamics of Innovation (Figure 9.2) – provides a means of visualising the interface between public (Government) and private (investor) interventions in the dynamics of innovation. Secondly, the innovation policy recommendations should

***Figure 9.2*** *– Policy Stages in the Dynamics of Innovation*




Source: adapted from Foxon *et al.*, 2004

[29] For a good overview of factor analysis see Rummel, R.J., 1970. *Applied Factor Analysis*. Evanston: North Western University Press.

be viewed holistically in terms of relevance (addressing the challenges), coherence (fit-for-purpose, and with each other), and inclusive (concerning Actors). Thirdly, policy instruments arising out of recommendations, and decided on by Government, have to be governed effectively and efficiently.

In general the results from all Respondents (ALL) are reported (unless otherwise stated) and, where appropriate, the results are reinforced by analysis of the individual sets of Actors. Throughout the reporting and discussion of results and implications the terms Respondents and Actors are used interchangeably. Due to 'round' up, cross-tabulations and particular analytical perspectives, not all summations of figures necessarily total 100%.

To depict and distinguish, within the presentation and discussion, the variables of the survey, the factors and policy dimensions from the statistical analysis, the following convention is used: (i) variables are depicted in single quotation marks ('Variable'); (ii) factors in single arrow brackets (<Factor>); and (iii) dimensions in double arrow brackets (<<Dimension>>).

To portray inter-, intra-linkages, the convention used, for example, is as follows:

- Government inter-linkage with Knowledge-Based Institution; proactive inter-linkage i.e. Government to Knowledge-Based Institutions is GOV-KBI, passive inter-linkage (from government perspective) KBI-GOV,

- Government intra-linkage GOV-GOV.

### 9.5.1 Research Institutions' Linkages with the Production System and Level of Innovativeness of Business Enterprises

With respect to innovation as a dynamic function of knowledge emerging from research, science and technology, and innovativeness in the production system of the economy (Gordon., 2012), the role of RIs is paramount[30]. Regarding the linkages between RIs and the production system, as well as the innovativeness of BEs[31], irrespective of the strength and direction of the linkages between RIs and the production system, 91.9% of ALL GNSI Respondents indicate very low levels of innovativeness of BEs. Only 3.9% of ALL Respondents indicate that the linkages are very strong and that there are very high levels of innovativeness of BEs. This finding is robustly supported by MHTI and KBI Respondents, respectively 90% and 95.5% of whom indicate that there are very low levels of innovativeness in BEs.

The policy implications of the disconnect between RIs and the production system, as well as the low levels of innovativeness of BEs are: (i) there are at best very few, and at worst no externalities arising from the public goods from supporting RIs; (ii) the signaling mechanisms by which RIs respond to the market on the one hand, and on the other hand, the production system and BEs make demands on RIs are at best intermittent, and at worst dysfunctional; (iii) the sales and marketing orientation of RIs with respect to their stock of intellectual property is poor, and hence their exploitation of knowledge assets is very limited; (iv) the flows of intellectual property from RIs to the production system are stymied; and (v) the potential for RIs to earn patent, license and royalty fees from intellectual property rights are unrealised.

The policy recommendations relevant to these deficiencies are: (i) reform of governance in RIs (and by implication KBIs) to enhance excellence in research based on performance measures tied to the funding of RIs and KBIs[32]; (ii) shift funding of RIs and KBIs to performance-based funding as a function of RIs and KBIs engagement with MHTI in terms of collaborative research, product development, Licensing, Patent and Royalty fees (LPRs), and provision of technological development services to MHTI; (iii) re-orient funding of RIs and KBIs toward competitive grants tied to RIs and KBIs – MHTI relationships; (iv) require RIs and KBIs to create intellectual property rights (IPRs) management offices funded on performance, for example, on in-coming LPRs; (v) require science, technology, engineering, mathematics and information technology (STEMIT) doctoral and post-doctoral studies funded by Government scholarships[33] to be embedded in a MHTI firm; (vi) selectively tie fiscal and monetary incentives available to MHTI to the hiring of STEMIT post-graduates and embedding of doctoral and post-doctoral studies; (vii) allow RI and KBI researchers to exploit discoveries commercially through amended contract conditions that require such performance; (viii) increase the management autonomy of RIs and KBIs and the autonomy of their relationships to MHTI; (ix) require boards of RIs and KBIs to include CEOs from MHTI; (x) set funding of RIs and KBIs research programmes within a framework of competitive grants based on triangulation (KBI-RI-MHTI consortia) and aimed at increasing multidisciplinary R&D; (xi) create a STEMIT Human Capital Mobility Fund for incentivizing the movement of STEMIT personnel from RIs and KBIs to MHTI and vice versa; and, (xii) reform all STEMIT curricula and courses to include an industry placement component ('thin' or 'thick' sandwich of three months or six months per academic year, respectively).

**Survey Analysis:** Very Weak linkages between RI and the production system.

**Policy Implication:** Little or no externalities from the public goods of funding RI.

**Policy Recommendation**: Reconfigure funding of RI to a performance-based structure.

[30] "A review of U.S. government spending on international S&T collaboration as a way to gain insight into how a developed country spends money on these types of projects: "the United States spends about 50 percent of global funds dedicated to R&D", see Wagner, C.S. Brahmakulam, I. Jackson, B. Wong A. and Yoda, T., 2001. *Science and Technology Collaboration: Building Capacity in Developing Countries?* Santa Monica: RAND Publications, Science and Technology, p.6.

[31] This result is significant at the 99.9% confidence level.

[32] For example ranking of RI and KBIs (institutions and departments therein) on research outputs, publications, patenting, license and royalty fees and funding on a sliding scale of performance-funding. That is, higher performance attracts disproportionately more funding while lower performance is penalised by disproportionately less funding. See for example UK ESRC research and teaching ranking of UK KBIs. (See for example: UK ESRC Research Assessment Exercise).

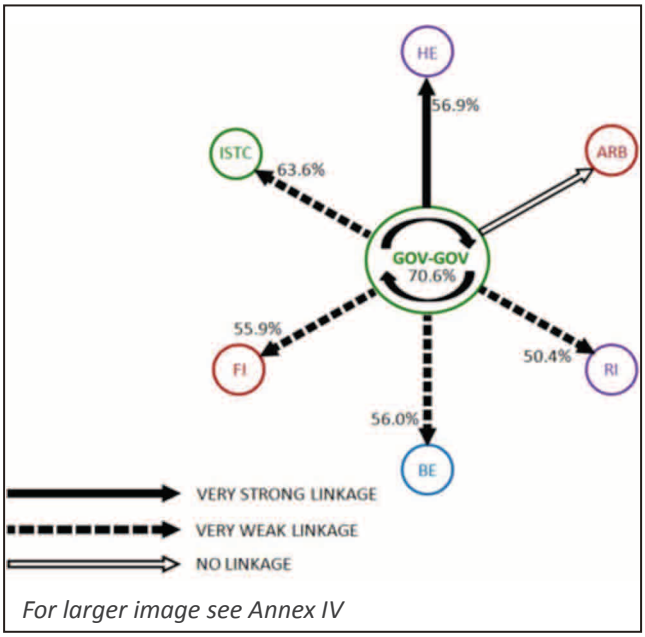
[33] This is in concert with the Government of Ghana directive to "emphasis on Mathematics, Science and Technical education, the MASTESS programme will sponsor 2,000 more beneficiaries during the 2012/2013 academic year"(Government of Ghana Budget 2012., pg. 432).

### 9.5.2 Importance of GNSI Actor and Strength of Inter-, Intra-Actor Linkages

The relationship between the importance of GNSI Actors and the strength of inter-, intra-Actor linkages is analysed firstly, with the perspective of whether the links are very strong or very weak. Secondly, from an Actor's perspective of the linkages other Actors have between themselves. Thirdly, from each Actor's perspective (Actor-centric view) of the linkages it has with other Actors. This is reported both in terms of very important-very strong (VI-VS) and very important-very weak (VI-VW).

The GNSI is analysed in terms of all Actors and individual Actors as Respondents, respectively. This provides insights into whether the Actors have a significant perception of the NSI variables being examined, the relative distribution (spread of linkages), density (number of linkages) and balance (uni-, bi-directional) of linkages within the GNSI. Each is addressed below.

***Figure 9.3*** *– Government Inter-, Intra-Linkages*




*For larger image see Annex IV*

#### 9.5.2.1 Actor Importance and Government [GOV] [ISTC] Inter-, Intra-Actor Linkages

From the perceptions of ALL Respondents, GOV inter-, intra-Actor linkages are generally very weak (in descending rank order) with ISTC, BEs, FIs and RIs, as indicated in Figure 9.3. There is no significant relationship between GOV and ARBs. However, GOV-GOV and GOV-HE linkages are very strong.

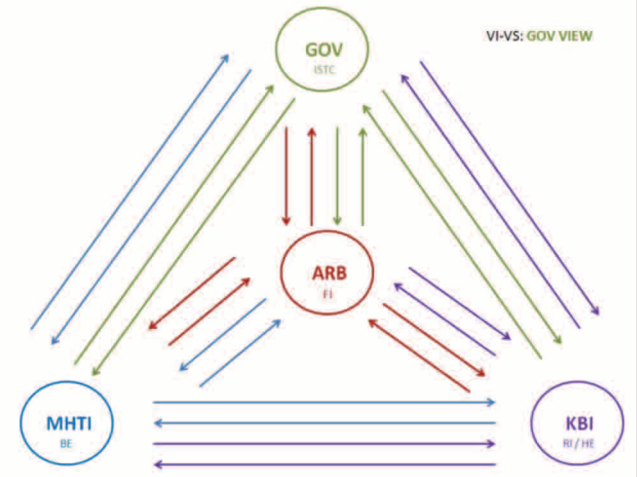
Figures indicate statistically significant percentage of all respondents assessing the inter-, intra- linkages.

From an individual Actor perspective, with respect to GOV-GOV intra-linkages, 66.7% of ARB Respondents perceive GOV-ISTC as VI-VS. In contrast 56.6% of KBI Respondents perceive GOV-ISTC as VI-VW[34]. Interestingly 46.3% of GOV Respondents perceive GOV-ISTC as VI-VW .

A critical finding, as indicated in Figure 9.4 is that GOV Respondents do not have a statistically significant perspective

[34] See Annex1–Importance of Actor and Strength of intra-Linkages.

***Figure 9.4*** *– Government Assessment of Other Actors' Inter-Linkages*




*For larger image see Annex IV*

of the inter-linkages among other Actors in the GNSI with respect to importance of Actor and strength of linkages.

The main policy implication is that the Government has at best a truncated view, and at worst no idea, of the key systemic relationships pertinent to innovation in the national economy. Notwithstanding previous studies on STI, this truncated view tends to occlude Government policy-makers from the variables of, and priorities in, policy for the overall governance of the NSI in terms of, for example: (i) coordination of Government actions and funding in STI; (ii) STI organisations' stability (human capital, funding support); (iii) institutionalising evidence-based policy-making (GNSI Survey applied longitudinally as an advanced assessment, monitoring and evaluation method for managing the NSI); (iv) evaluation of the mix of policy instruments; and (v) catalysts for higher networking densities across the GNSI.

The policy recommendations to address the very weak inter-linkages of Government and Government's truncated view of the systemic NSI relationships are: (i) the Ministry of Trade and Industry (MoTI) and the Ministry of Environment, Science and Technology (MEST) should become superordinated as the primary formulator and coordinator of all GNSI policy and strategy through a statutory inter-ministerial GNSI Policy Unit (GNSIPU), chaired by the two ministers and reporting to cabinet; (ii) the GNSIPU should have oversight of, and responsibility for, NSI monitoring, evaluation and assessment of GNSI Actors' performance[35]; (iii) establish a biennial standing conference (sponsored by the Government) on 'Innovation and Innovativeness in the National Economy' involving all four Actors in the GNSI[36]; (iv) the GNSIPU should be mandated with setting priorities, defining national (and regional) policy orientations, and budgetary appropriations concerning innovation[37]; (v) require that Government innovation policy-making formally and legally consults all GNSI Actors through a 'white' paper and 'green' paper process;

[35] The GNSIPU would need to develop research capacity to review best practise in industrialised as well as middle-income countries and emerging markets.

[36] From such a conference stakeholder fora will emerge to foster increased innovation policy coherence through strategic goals, business plans and managerial actions.

[37] This ensures enhanced policy co-ordination and reduces fragmentary relations between government and GNSI Actors.

and, (vi) establish a formal consultative process (six monthly) between the GNSIPU and MHTI (and industry associations), KBIs and ARBs regarding innovation policy.

**Survey Analysis:** Government has very weak linkages with other Actors in the GNSI.

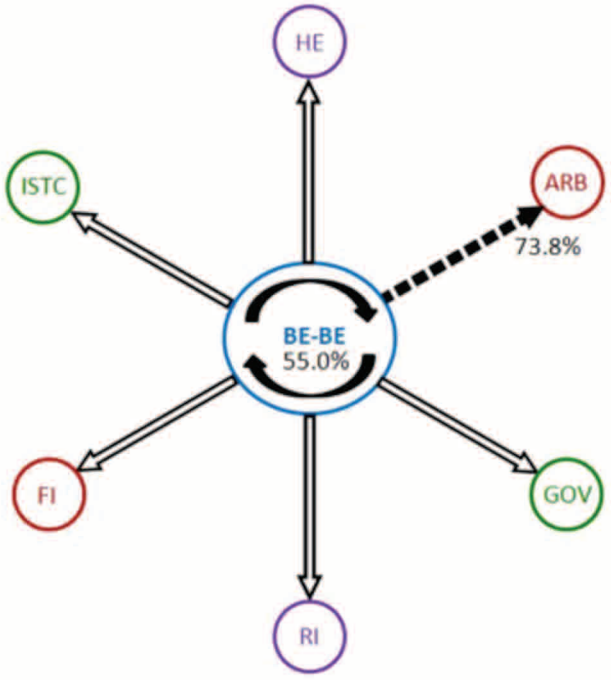
**Policy Implication:** Truncated linkages at best, at worst no idea of systemic relationships pertinent to innovation in the economy.

**Policy Recommendation:** Create an inter-ministerial GNSI policy unit charged with setting priorities, strategic goals, budgetary appropriations.

#### 9.5.2.2 Actor Importance and Medium and High-Tech Industry [MHTI] [BE] Inter-, Intra-Actor Linkages

From the perceptions of ALL Respondents regarding BE inter-, intra-Actor linkages there is only one significant linkage with ARB and this is perceived as very weak. This is depicted in Figure 9.5 below. Conversely very strong linkages are found between BE-BE.

***Figure 9.5*** *– Business Enterprise Inter-, Intra-Linkages*

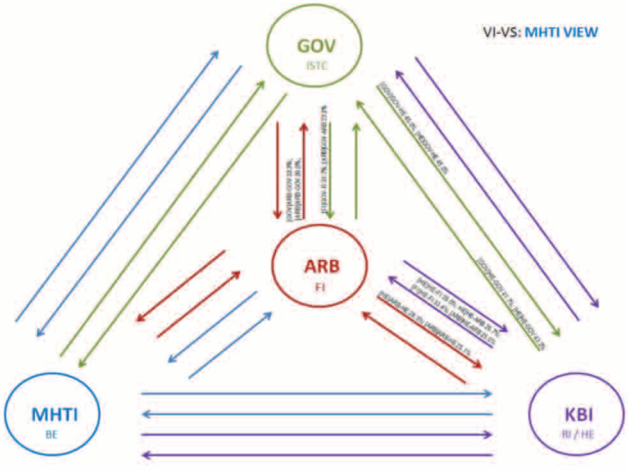



*For larger image see Annex IV*

From an individual Actor perspective, with respect to BE-BE intra-linkages, 51.7% of MHTI Respondents perceive BE-BE as VI-VS[38].

From the perspective of MHTI Respondents, as indicated in Figure 9.6 (in the minority <50%) the distribution of VI-VS Actor linkages is ARB-centric. However, there is a significant bi-directional relationship between GOV-KBI, while linkages between ARB and KBI and GOV are unidirectional. Interestingly there is no significant perception of bi-directional linkages between KBI-GOV.

***Figure 9.6*** *– Medium and High-Tech Industry Assessment of Other Actors' Inter-Linkages*




*For larger image see Annex IV*

The key policy implication of the relative isolation of Business Enterprise from other GNSI Actors is that industry in general is at best poorly able to, and at worst powerless to, influence the design, calibration and articulation of the mix of policy instruments for promoting and accelerating business research and development and institutional innovation. Specifically, Business Enterprises are remote from: (i) an inspiring role in setting public procurement policy; (ii) encouraging cooperation and collaboration between GNSI Actors, especially between ISTC and Industry Associations; (iii) prominence in the overall governance of the GNSI (strategic disposition, orientation and policy priorities); (iv) projecting to the Government the factor constraints to innovation they confront; (v) reviews of regulatory regimes that govern the relationship between public resources and the private sector with respect to innovation; (vi) enabling the removal of obstacles and impediments to public private-sector partnerships for innovation initiatives; and, (vii) being fully convergent with Government priorities with respect to demand-signals, as well as fostering human capital mobility from Business Enterprise to GOV (and from GOV to Business Enterprise) to enhance cross-sectors collaboration (notwithstanding the need to moderate potential conflicts of interest).

The policy recommendations to address the implications of very weak Business Enterprise inter-linkages with other GNSI Actors are, in concert with previous recommendations: (i) condition the management of indirect and direct support to Business Enterprise and MHTI (fiscal and monetary incentives, matching funds, subsidised loans and grants) and financial sector support (guarantees and venture capital) to Business Enterprise engagement with other GNSI Actors especially KBIs[39]; (ii) institutionalise the role of Business Enterprise in the policy governance of the GNSI through legal and formal consultative processes of 'white' and 'green' papers;

[38] See Annex 1 – Importance of Actor and Strength of intra-Linkages.

[39] In terms of MHTI–KBI indicators such as contracts, R&D projects, collaboration in product development, etc.

(iii) reconfigure public procurement policy to require pre-qualification to tender based on MHTI inter-linkages with other Actors, especially KBIs; (iv) recalibrate sector support to require formal collaborative arrangements between MHTI and public sectors, and KBIs and ARBs, under terms and conditions of matching resources from MHTI companies, RIs and regional Government[40]; (v) incentivise Industry Associations and Chambers of Commerce to create liaison offices that deal with KBIs, ARBs and GOV; and, (vi) incentivise mobility of personnel between private and public sectors by opening up the STEMIT Human Capital Mobility Fund to SMEs in MHTI.

**Survey Analysis:** Business Enterprises isolated from other Actors.

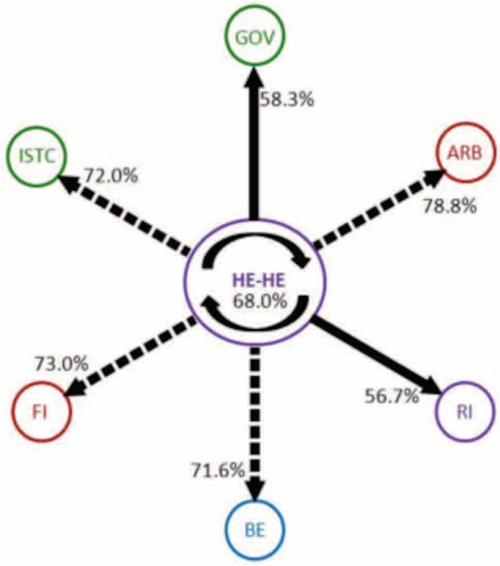
**Policy Implication:** Business Enterprise (MHTI) isolation leaves them far removed from the policy making process, particularly articulation and calibration of policy to industry needs.

**Policy Recommendation:** Condition the indirect and direct support to industry on engagement of MHTI with other GNSI Actors especially KBIs.

#### 9.5.2.3 Actor Importance and Knowledge-Based Institutions [KBIs] [HE][RI] Inter- Intra-Actor Linkages

From the perceptions of ALL Respondents, HE and RI inter-, intra-Actor linkages are generally very weak, and specifically, with respect to HE inter-linkages with ARBs, FIs, ISTC and BEs, as indicated in Figures 9.7 and 9.8. Concerning RIs there are no significant relationships between FIs, ARBs, ISTC and BEs. Conversely very strong linkages are found between HE-GOV and HE-RI. Concerning RI inter-linkages while RI-GOV is very weak, RI-HE is very strong.

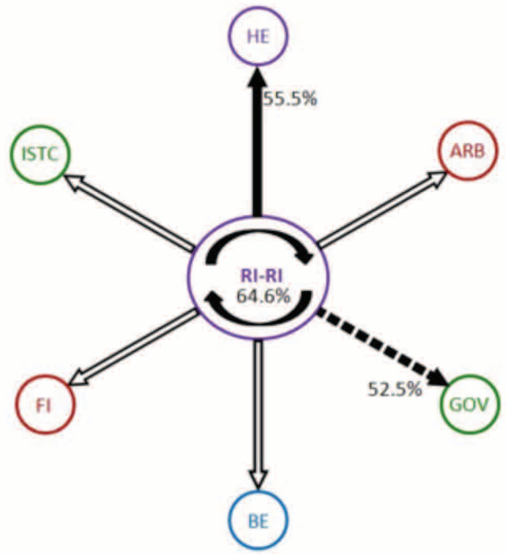
***Figure 9.7*** *– Higher Education Inter- Intra-Linkages*




*For larger image see Annex IV*

[40] In terms of knowledge transfers between the private and public sectors.

***Figure 9.8*** *– Research Institute Inter- Intra-Linkages*




*For larger image see Annex IV*

The finding of significantly VI-VW HE and RI inter-linkages is consistent with other studies noting that "there are few joint or collaborative projects" (UNCTAD, 2011, p.32).

From an individual Actor perspective, with respect to HE-HE intra-linkages, 48.2% of MHTI Respondents perceive HE-HE as VI-VS[41], for RI-RI intra-linkages, 67.5% of KBI Respondents perceive RI-RI as VI-VS; and with respect to RI-HE/HE-RI intra-linkages, 61.3% and 59.8% of KBI Respondents perceive RI-HE and HE-RI respectively as VI-VS[42].

From the perspective of KBI Respondents, indicated in figure 9.9, (in the minority <50%) the distribution of VI-VS Actor linkages is ARB-centric. Furthermore, the linkages are perceived as unidirectional. Interestingly there is no significant perception of the linkages between MHTI and GOV by KBIs.

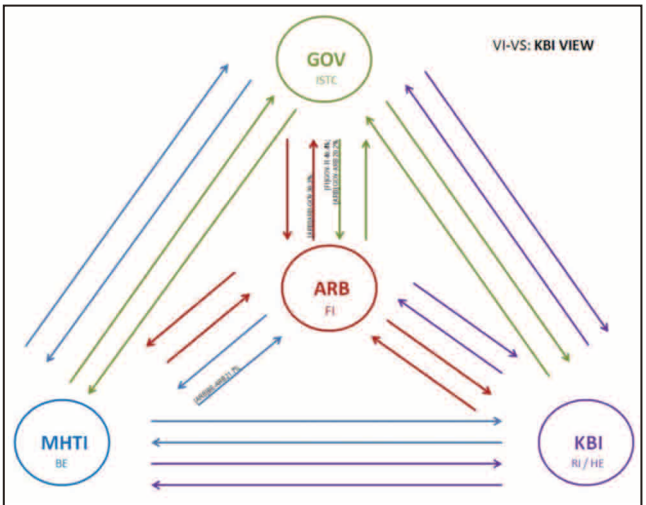
The key policy implications are Knowledge-Based Institutions are at best poorly able, and at worst unable, to tap into and exploit the stocks and flows of knowledge. Secondly, their intermediation role in the relationships between MHTI and GOV is severely limited (hence their reduced ability to influence innovation policy).

And specifically, Knowledge-Based Institutions (HE, RI) are occluded in terms of: (i) participation in research and development networks; (ii) managing the supply-side of advanced human capital resources, and Data, Information, Statistics and Knowledge (DISK) to MHTI; (iii) responding effectively to the demand-side of human resource

[41] It is instructive to note that this view from MHTI is supported by UNCTAD (2011, p.36) which finds the following weakness in Ghana's system of innovation concerning KBI: (i) R&D institutes are under resourced; (ii) technology support and regulatory agencies are not adequately resourced and linked to R&D institutes; (iii) financial institutions are not strategically involved in or linked to R&D; (iv) poor links between private companies and public R&D, limited in-house R&D and innovation activities in the private sector; (v) lack of clear strategy and institutional leadership to build or improve R&D institutes; (vi) lack of cabinet champion for Science and Innovation policy; (vii) no clear strategy for improving infrastructure for R&D and engineering; (viii) lack of engagement of financial institution in R&D and technological innovation; (ix) no budget dedicated to Science, Technology and Innovation policy programmes.

[42] See Annex 1 – Importance of Actor and Strength of intra-Linkages.

***Figure 9.9** – Knowledge-Based Institution Assessment of Other Actors' Inter-Linkages*




*For larger image see Annex IV*

requirements from MHTI; (iv) priorities in specialisation (from other Actor perspectives); (v) inter-HE institutional competitiveness; (vi) pedagogic and curricula programme developments that serve other Actors, especially MHTI; (vii) alignment of competitive enhancement of Knowledge-Based Institutions with regional development priorities; and, (viii) strategic development of Knowledge-Based Institutions' own capacities and capabilities.

The policy recommendations to address the absent, perforated and very weak Knowledge-Based Institution inter-linkages are, in concert with those for RI: (i) eliminate regulations and contractual obligations that prevent Knowledge-Based Institution personnel (STEMIT researchers) from participating in industry R&D; (ii) use the STEMIT Human Capital Mobility Fund to incentivise movement of Knowledge-Based Institution personnel to Government policy organs, MHTI and ARBs, and vice versa; (iii) require Knowledge-Based Institutions to hold annual 'open' days with MHTI and ARBs involvement where the results of R&D from RIs and STEMIT undergraduate, post-graduate, doctoral and post-doctoral projects/studies are displayed for the purposes of generating IPRs; patent, license and royalty fees through collaborative product development and commercialisation; (iv) require Knowledge-Based Institutions in concert to host a biennial Standing Conference on 'the role of Knowledge-Based Institutions in innovation' involving MHTI, ARBs and GOV; (v) move sequentially away from block grants toward competitive funding for Knowledge-Based Institutions based on performance criteria related to their engagement with MHTI and other GNSI Actors[43]; (vi) require Knowledge-Based Institution STEMIT departments in collaboration to conduct technology foresight exercises with MHTI, ARBs and GOV[44]; (vii) evaluate Knowledge-Based Institution performance for R&D 'top up' grants on the basis of triangulation, STEMIT inter-departmental collaboration and academic–industry co-operation indicators; (viii) require Knowledge-Based Institutions to create, alongside IPR offices, MHTI liaison offices to intensify academic–industry networking; (ix) require Knowledge-Based Institution STEMIT curricula redesign to meet market demand to include formal consultative process involving MHTI, in order to attract Government funding; and, (x) reform the academic human resources policy for recruitment to enable MHTI practitioners and executives to teach in STEMIT programmes, and permit sabbaticals in MHTI by STEMIT academics.

**Survey Analysis:** Only traditional relationships present (RI-HE, HE-GOV), all other relationships are very weak or non-existent.

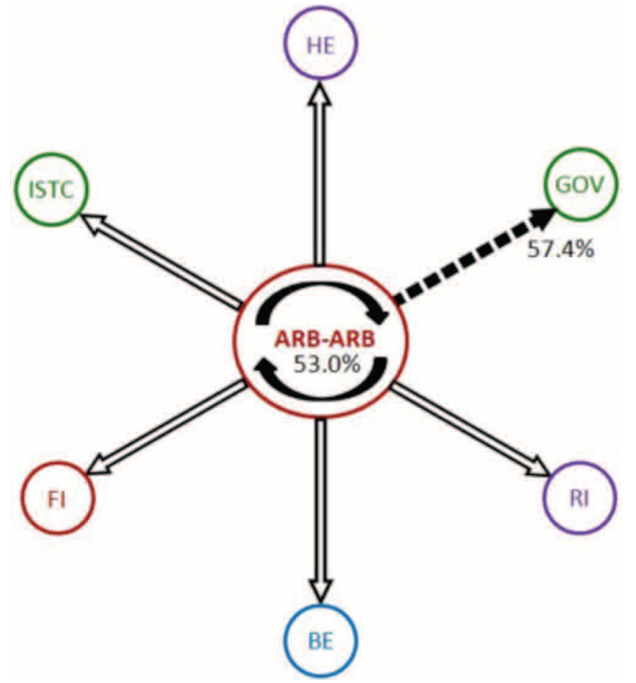
**Policy Implication:** Knowledge–Based Institutions, at best poorly connected, and at worst unable to tap into, and exploit, stocks and flows of knowledge.

**Policy Recommendation:** Incentivise the mobility of STEMIT academics to MHTI, and GOV, and use performance-based funding.

#### 9.5.2.4 Actor Importance and Arbitrageur [ARB][FI] Inter-Intra-Actor Linkages

From the perceptions of ALL Respondents regarding ARB inter-, intra-Actor linkages, as seen in Figure 9.10 above, there is only one significant linkage with GOV and this is perceived as very weak. ARB-ARB intra-linkages are assessed as very strong.

***Figure 9.10** – Arbitrageur Inter- Intra-Linkages*




*For larger image see Annex IV*

From an individual Actor perspective, with respect to ARB-FI intra-linkages, 45.8% of KBI Respondents and 44.9% of MHTI Respondents perceive ARB-FI as VI-VS[45].

[43] Such as IPRs returns, collaborative R&D, collaborative publishing, commercialisation indicators.

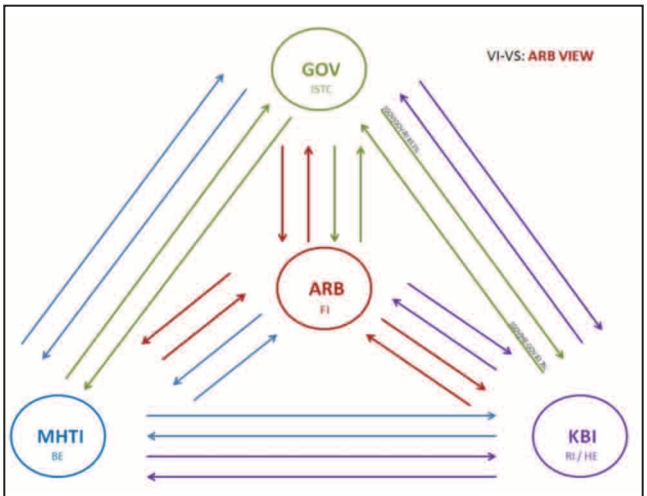
[44] This has the effect of catalysing networking across the GNSI, and deepening and thickening relationships to assist in creating and/or enhancing coalitions that advocate change.

[45] See Annex 1 – Importance of Actor and Strength of intra-Linkages.

From the perspective of ARB Respondents, as indicated in Figure 9.11, the distribution of VI-VS Actor linkages is GOV-centric with a perception of a significant bi-directional relationship between GOV-KBI.

The key policy implication is that Arbitrageurs, as the pivotal category of intermediary institutions in the GNSI, are at best performing poorly and at worst not executing their intermediation role as knowledge brokers and venture capitalists. Specifically, Arbitrageurs are: (i) isolated from KBI (HE, RIs) – the primary sources of DISK – and therefore are severely

***Figure 9.11*** *– Arbitrageur Assessment of Other Actors' Inter-Linkages*




*For larger image see Annex IV*

limited in their role of intermediations; (ii) debilitated in their role of linking ISTC to BEs via private equity; and, (iii) occluded from increasing the technological capacity of BEs through knowledge brokering.

Policy recommendations to address the almost total isolation of Arbitrageurs from other Actors in the GNSI, notwithstanding the relatively small size of the capital and financial industry in Ghana[46], are to: (i) condition indirect and direct support to the capital and financial industry on Arbitrageur engagement with MHTI, KBIs and ISTC; (ii) use direct support measures (subsidised loans and grants) to match venture capital, private equity investments in KBI 'spin-offs' and incubator projects; and, (iii) recalibrate the tax code to permit private equity and venture-capital investments in KBI and MHTI R&D activities to be written off against profits.

**Survey Analysis:** Arbitrageurs are isolated from other Actors.

**Policy Implication:** Arbitrageurs are severely limited in their role in intermediation.

**Policy Recommendation:** Incentivise Arbitrageurs to link between KBIs and MHTI.

[46] All the more reason to ensure the active participation of Arbitrageurs in the GNSI.

### 9.5.3 Importance of GNSI Actor and Strength of Actor-Centric Linkages

The following section maps GNSI Actor's assessment of their own inter-linkages and is presented as bullet points for ease of reading. The policy implications are presented thereafter, followed by the policy recommendations at the end of the section.

- It is to be recalled that GOV Respondents have no significant assessment of other Actors' inter-linkages (see Figure 9.4); that the MHTI view is notable for the absence of significant relationships KBIs–GOV (see Figure 9.6); that KBIs do not have a significant assessment of MHTI–GOV inter-linkages (see Figure 9.9 above); and ARB do not have a significant assessment of KBIs–GOV, MHTI–KBIs, MHTI–GOV inter-linkages (see Figure 9.11).

- There is no significant perception by MHTI of KBI-GOV relations, however mapping the Actor-centric data regarding Actor importance and linkages, that is, the Actors' perceptions of its own relationships (see Figure 9.12), the majority of KBI perceive VI-VS relationships between KBI-GOV and GOV-KBI with the exception of RI-ISTC linkages (only 26.4% KBI assess this as VI-VS). Clearly these two views of MHTI and KBI are asymmetric.

The policy implications are: (i) there is insufficient information exchange between MHTI and KBIs with respect to KBI-GOV relations, which raises the policy question of whether there is a MHTI/KBI forum/standing conference that could help address and facilitate information exchange; (ii) ARBs are isolated from the GNSI and play no significant role in terms of intermediating knowledge transfers through modalities such as the financial, or venture capital, frame-working of IPRs, and licensing regarding the IPRs either emanating from KBI, or between KBI and MHTI; (iii) the ARB intra-linkages, perceived as VI-VS by Respondents, have very few (if any) significant externalities. It should be noted that from an Actor-centric view, ARBs indicate only two proactive linkages with respect to GOV and MHTI, notably [GOV]ARB-GOV, 83.4%, and MHTI [BE]ARB-BE, 50.0%.

- With respect to MHTI perception of the relationship between GOV-ARB-KBI, in which there are more significant relations (ARB-GOV, GOV-ARB, ARB-KBI, KBI-ARB) than GOV-KBI or KBI-GOV. The minority of MHTI perceive VI-VS inter-linkages. There are ten significant linkages in GOV-ARB-KBI (unidirectional) compared to two GOV-KBI (bidirectional) (see Figure 9.6 above).

The policy implications arising from this asymmetry concern: (i) the absence of reciprocating relations of communications, coordination and exchange functions that are formalised through, for example, well-functioning standing committees and conferences between GOV-ARB-KBI; and, (ii) operative high-performance councils on Science, Engineering Technology and Innovation, as well as on economic and social research, and on the 'knowledge brokering' role of ARBs (FI).

- With respect to the Actor-centric view regarding VI-VS inter-linkages (see Figure 9.12 below), there are no significant relations between ARBs and KBIs, only one ARB-GOV, and one ARB-MHTI.

The key policy implication is that the isolation of ARBs implies, at best, a very limited intermediary role in the creation of stocks of DISK, and as pumps for flows of DISK through the GNSI. At worst, ARBs have no functional intermediation role. Specifically: (i) the absence of significant linkages ARB-KBI, KBI-ARB means that ARBs do not have access to DISK created by and held within KBI. Therefore, ARBs are prevented from adding value to the DISK by acting as conduits (framed by financial considerations) to MHTI or investing directly in KBI hosted spin-offs; (ii) the [BE]ARB-BE linkage has less depth to it than otherwise in the absence of ARB access to DISK from KBI; (iii) the [GOV]ARB-GOV linkage is likely to be devoid of the practicability of ARBs being able to persuade convincingly GOV towards policies that enhance the stocks and flows of knowledge in, and through, the GNSI (i.e. from KBI to MHTI directly, or indirectly, via ARB, e.g. through advocacy and lobbying pressure).

- Notwithstanding the overall weakness of inter-linkages among Actors in the GNSI, from a triangular perspective the relationship GOV-ARB-KBI, the densest of this relationship is along the axis KBI-GOV. This reflects the traditional role of GOV in funding KBI (HE, RI) (see Figure 9.12 below).

The policy implications of this public goods provision by GOV, in the context of the isolation of ARBs from the GNSI, and hence their insubstantial intermediating role and overall VI-VW systemic inter-linkages, are: (i) very low returns from the expenditure in treasury, organisational effort and transaction costs [47] [48] [49]; (ii) the externalities – the fundamental reason for providing the public goods in the first place – are extremely limited thus reducing considerably the effectiveness and efficiency of the GNSI. In this context the UNIDO quality infrastructure project in Ghana may be considered exceptional[50].

- Importantly the perception of KBI-GOV relations by KBI is asymmetric to the perception of GOV-KBI relations. KBI perceive a bi-directional relationship, whereas GOV perceives no significant relationship (see Figure 9.12 below).

Policy implications pointing to the asymmetry between KBIs and GOV regarding their inter-linkages have profound consequences. These policy implications are: (i) the GOV framework of incentives for KBIs (fiscal, monetary, regulatory and performance) is mostly ineffective in that GOV demands little from KBI in return for providing financial support to KBIs (and students) in STEMIT; (ii) GOV supported ISTC inter-linkages with KBIs are largely ineffective (with respect to [ISTC] RI-ISTC, 61.4% of KBI Respondents indicate VI-VW); (iii) the [policy] performance required from KBIs by GOV is limited at best, and at worst has no dimensions that encourage KBIs to engage proactively with other GNSI Actors through modalities such as participating in rankings of STEMIT departments and faculties, conditioning financial support (research grants etc.) on output performance (journal publications, patents filed and awarded, license, fees and royalties received and paid, IPRs commercialised, and establishing IPRs offices in KBI to engage with MHTI, etc.); (iv) across the board recalibration of STEMIT under- and post- graduate courses to the needs of MHTI via combining intra-mural course work with extra-mural industrial work experience, and in GOV supported biennial exhibition of KBI IPRs to MHTI; (v) reconfiguring the national service programme relevantly toward internships in MHTI for STEMIT students; (vi) conditioning financial support (research 'top up' grants, etc.) on joint research with MHTI; and, (vii) redesigning final year undergraduate and postgraduate projects in STEMIT to be inter-disciplinary involving a minimum of three, and maximum of six, students to address a specific local problem in the vicinity (e.g. building water sanitation, drainage, waste recycling, etc.) in order to seed, and initiate, the potential for graduates to create their own employment.

- Whereas the majority (51.1%-56.3%) of KBI Respondents perceive KBI-GOV (bidirectional) as VI-VS, only a minority (26.4%) of KBI Respondents perceive the crucial transformational RI-ISTC linkage as VI-VS (the majority of KBI Respondents 61.4% assess [ISTC]RI-ISTC as VI-VW) (see Figure 9.12 below).

The policy implications of this VI-VW inter-linkage between RI-ISTC include: (i) truncated relations with demand and factor markets, and with MHTI in the commercialisation of KBI's IPRs, especially in the light of the absence of significant KBI-ARB, MHTI(BE)-GOV(ISTC), MHTI(BE)-KBI(RI) inter-linkages; (ii) VI-VW KBI passive [HE]BE-HE inter-linkages; (iii) from a stocks

[47] %GDP spent on R&D – South Africa 0.9, Ghana 0.2, Kenya 0.4, Tanzania 0.4, Botswana 0.5. Sources: The World Bank, 2012. *World Development Indicators.* Research and Development Expenditure % of GDP, 2005-2007. Washington D.C: The World Bank (Research and Development Expenditure % on GDP, 2005-2007).

[48] The expenditure on KBI by government with respect to research and development is erratic (Adarkwa, 2008, in UNCTAD, 2011) while allocations to CSIR-STIPR are utilised 81% for staff costs and 9% for research.

[49] According to UNCTAD (2011) the low expenditure on R&D is hardly compensated for by either the private sector efforts which amount to about 2% of all funding for R&D or Arbitrageurs. These figures represent the importance given to Science, Technology, Engineering, Mathematics and Information Technology (STEMIT) in national priorities; and the serious challenges facing the implementation of the technology and innovation policies indicated in the Ghana Industrial Policy.

[50] USGHA06005: TRADE CAPACITY BUILDING FOR GHANA – Most developing countries and economies in transition have liberalised their markets in the hope to achieve export-led growth. However, reducing tariffs and quotas did not lead to a tangible increase in developing country exports. Excepting the 'BRICS': according to UNIDO for developing country exports to grow substantially, countries should be assisted in three areas: improving supply-side capacity and competitiveness, proving conformity with market requirements, and enhancing connectivity with world markets. To assist developing countries in the above three areas, UNIDO and WTO launched a pilot project in nine countries to identify priority sectors and/or products with high and strategic export potential facing barriers to trade and trade-capacity-building weaknesses. Ghana was chosen as one of the pilot countries as it faces a number of obstacles to the export of products where a comparative advantage exists. Those obstacles lay on the side of the productive capacities (supply side) that do not produce according to international market requirements, in the area of standards and conformity assessment services, which are not recognised internationally, and reveal a lack of integration into the multi-lateral trading system. The trade capacity building project covers these deficiencies. The present project builds on the results of the assessment of potential sectors/products and proposes concrete measures to expand Ghanaian exports in the priority areas through an improvement of supply-side capacity to produce to international standards and technical regulations, the establishment and upgrading of the conformity assessment infrastructure (calibration and testing laboratories, enterprise certification).

and flows perspective, the stocks of KBI IPRs find little or no receptive outlets either in ISTC or MHTI, and hence there is little or no flow of intellectual property and knowledge within the GNSI; and, (iv) as with GOV performance requirements from KBI, that from RI and ISTC is also very limited.

- MHTI see a significant bi-directional relationship between GOV and KBI, but none with respect to KBI-GOV (see Figure 9.6 above). However, GOV Respondents do not mirror this view, while KBI Respondents do have a view of KBI-GOV inter-linkages (see Figure 9.12). This divergence between MHTI and GOV with respect to GOV-KBI, on the one hand; and asymmetry between MHTI and KBI with respect to KBI-GOV inter-linkages is indicative of discordance within the GNSI and its pre-adolescent stage of evolution in terms of the Triple Helix type 4 of GOV-KBI-MHTI-ARB transactional and transformational linkages, on the other hand (see Figure 9.12).

Policy implications from the policy analysis, and of the Actor-centric view, of the Triple Helix type 4 relations include: (i) conspicuous gaps in GOV-MHTI and ARB-KBI (and vice versa) linkages. This has severe consequences for the operation of policy for Science, Engineering, Technology and Innovation through the five levels and means of policy enforcement – communications, co-operation(s), co-ordination(s), command and control (via legislation, incentives, regulation and sanction); (ii) noting that GOV Respondents have no significant assessment of inter-linkages among other Actors in the GNSI, it would appear that the policy levers available to GOV are, at best, articulated insufficiently well, and at worst too remote for effective policy craft and efficient policy direction; (iii) notably ARB mirror MHTI view of a significant bi-directional inter-linkage GOV-KBI in terms [GOV]GOV-RI and [GOV]HE-GOV; [GOV]GOV-HE, [HE]GOV-HE and [GOV]HE-GOV, [HE]HE-GOV (see Figures 9.6 and 9.11 above); (iv) however, the absence of Actor-centric ARB-KBI (vice versa) and GOV-MHTI (vice versa) inter-linkages implies limited ability on the part of GOV to enforce policy with respect to KBI-ARB inter-linkages (see Figure 9.12) (and hence behaviour regarding innovativeness), and MHTI regarding targeting early adopters and early majority in the diffusion of innovation paradigm.

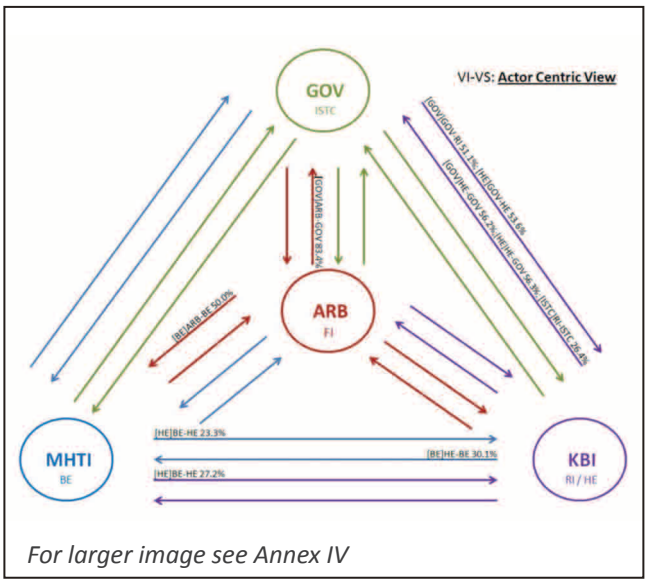
In summary, the policy implications of the gaps identified in the GNSI from the preceding section may be grouped into: (i) information asymmetries; (ii) lack of significant externalities; (iii) glacial flows of DISK in the GNSI; (iv) an ineffective framework of incentives; and, (v) unarticulated policy levers.

- Figures 9.12 and 9.13 map and measure statistically significant Actor-centric assessment of their inter-linkages with other Actors (i.e. how one Actor views its inter-linkages with another Actor) in proactive that is for example from the perspective of GOV, (GOV-KBI) or passive that is for example (KBI-GOV), along the dimension importance of Actor and strength of Actor-Actor inter-linkages measured as VI-VS and VI-VW. The diagrams require viewing in tandem.

- The first diagram (see Figure 9.12) measuring the dimension along VI-VS shows that only along the axis KBI-GOV is there a majority of KBI Respondents' assessment that their proactive KBI-GOV and passive GOV-KBI inter-linkages are VI-VS. And this is seriously moderated but the majority of KBI Respondents (61.4%) who assess the [ISTC]RI-ISTC as VI-VW (see Figure 9.13). The first diagram also shows that the only other majority assessment is by ARB Respondents regarding the proactive [BE]ARB-BE (50.0%), and [GOV]ARB-GOV (83.4%) inter-linkages. All other assessments that are statistically significant indicate VI-VW bi-directional (proactive and passive) inter-linkages MHTI-KBI. And, with respect to KBI-MHTI, the majority of KBI Respondents (64.4%) assess the passive inter-linkages [HE]BE-HE as VI-VW.

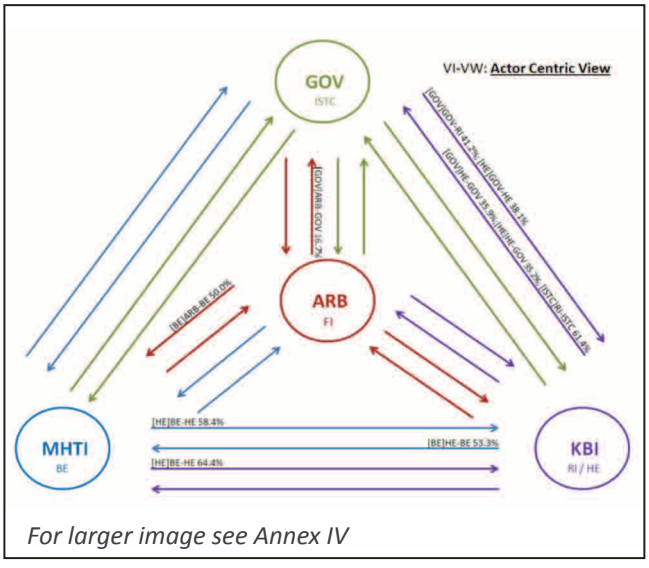
The policy implications of this asymmetrical dimension of Actor importance and strength of Actor-Actor inter-linkages include: (i) a GNSI that is seriously deficient along the axes GOV-MHTI (vice versa), GOV-ARB, GOV-KBI, ARB-KBI and (vice versa), MHTI-ARB, in bi-directional terms (proactive and passive inter-linkages); (ii) this deficiency is compounded by the isolation of ARB, absence of MHTI-ARB, and KBI passive MHTI-KBI, inter-linkages; (iii) the inter-Actor dialogue on innovation and innovation policy is therefore far from complete with respect to GOV-MHTI, GOV-ARB, GOV-KBI, MHTI-ARB (vice versa) and ARB-KBI (vice versa) inter-linkages; (iv) the

***Figure 9.12*** *– Actor-Centric Assessment of Inter Linkages (Very Important- Very Strong)*




*For larger image see Annex IV*

***Figure 9.13*** *– Actor Centric Assessment of Inter Linkages (Very Important- Very Weak)*




*For larger image see Annex IV*

lateral side of the Triple Helix type 4 (GOV-MHTI) on which innovation policy and industrial innovation should be manifest is missing; and, (v) the side on which financial intermediation pumps creative ideas and DISK to, and facilitates IP commercialisation in, markets is also largely missing.

The policy recommendations to address these asymmetries, defects and deficiencies are; (i) initiation of a formal consultative process on innovativeness and innovation in the national economy involving GOV, MHTI, KBIs, and ARB using 'white' and 'green' paper protocols, as well as Standing Conferences; (ii) ensure accountability standards, managerial requirements and governance structures are harmonised across KBIs (RI, HE); (iii) eliminate conditional constraints preventing public-sector institutions from engaging in STEMIT activities in conjunction with the private sector; (iv) adopt common performance agreements (linked to funding), that have external relationship indicators, across KBIs (RI, HE); (v) generate economies of scale and scope by dissolving poor performance RI, merging middling-performance RI and selectively corporatizing high-performance RI; (vi) create a Science, Engineering, Technology, and Innovation Research Council (SETIRC) chaired at vice-presidential level to signal seniority to re-strategise the purpose and functioning of national agencies and research institutes towards innovativeness in the national economy[51]; (vii) adopt an open to all KBI Information Reporting System which is centralised and posts information on research (topics and achievements), curricular developments, graduates (output, enrolment and employment rates per discipline), full-time faculty rates, and scholarships; (viii) adopt advanced monitoring and evaluation practices for evidence-based assessment of KBIs and policy instruments to address the disconnects between research and HE, and incentives and performance; (ix) accelerate and elevate the strategy for e-Government[52]; (x) perform an audit of the policy mix of instruments and incentives aimed at increasing innovativeness[53]; (xi) reconfigure public sector procurement policy, terms and conditions to require triangulation between MHTI, KBIs and ARBs[54]; (xii) use regional development funds to triangulate regional government, industry associations and KBIs for developing clusters[55]; (xiii) ensure MHTI, KBIs and ARB representation on the SETIRC (Chambers of Commerce and University Councils); and, (xiv) adapt the Foreign Direct Investment (FDI) regulatory regime to adjust its modal neutrality[56] to favour business collaboration and R&D joint ventures between foreign investors, MHTI and KBIs.

[51] The GNSIPU and SETIRC would have to work closely together. SETIRC would need to set out the strategic short,-medium-and long-term themes for innovativeness in the national economy such as; agricultural productivity; information technology; material science; etc., arrived at through foresight exercises executed by KBIs. GNSIPU would need to facilitate the necessary co-ordination to achieve goals.

[52] The ICT4AD policy (2003, pp.41-43, pp.57-59) requires updating with quantitative targets.

[53] The use of the GNSI longitudinal policy mapping instrument in order to measure convergence or divergence in terms of policy outcomes.

[54] Such conditionalities tend to thicken the triangular relationship through the requirement of a R&D component as well as a venture capital component to make public procurement innovation oriented.

[55] KBIs foresight exercises will assist in identifying such.

[56] Modal neutrality refers to policies designed to allow investors to decide for themselves how best to service the markets they enter.

**Survey Analysis:** Absent or asymmetric inter-linkages between GNSI Actors.

**Policy Implication:** Nexus of innovation policy and industrial innovation absent from the GNSI model.

**Policy Recommendation:** Reconfigure public procurement terms and conditions to require triangulation between MHTI, KBIs and ARBs.

### 9.5.4 Strength of Inter-, Intra-Actor Linkages and Level of Innovativeness of Business Enterprises

Regarding the linkages and the level of innovativeness, the articulation of the Triple Helix type 4 Actors is crucial in terms of robustness, symmetry and reciprocating exchanges of value in the GNSI. The analytical mapping and measuring that follows examines the strength of GNSI Actors' inter-, intra-linkages in relation to the level of innovativeness of Business Enterprises in order to disclose the predominant patterns and the implications they carry.

#### 9.5.4.1 Government [GOV] [ISTC] Inter-, Intra-Linkages – Level of Innovativeness of Business Enterprises

- Bearing in mind that GOV as a key Actor in the GNSI has, or should have, links with other Actors in the system, regardless of the strengths (or weaknesses) of GOV inter- and intra-linkages over 91.7% of ALL Respondents indicate very low level of innovativeness of BEs[57].

- Notably only 5.1%-6.9% of ALL Respondents assess that GOV inter- and intra-linkages are very strong and that there are very high level of innovativeness of BEs . Although an encouraging range of 20.6%[58] to 57.7% of ALL Respondents indicate very strong GOV inter- and intra-linkages, however, these same Respondents also indicate that there is very low level of innovativeness of BEs.

- Even more strikingly, a range between 34.3% and 71.3% of ALL Respondents indicates that GOV inter- and intra-linkages are very weak and there is a very low level of innovativeness of BEs[59].

- With respect to the crucial GOV-BE linkages 92.1% of ALL Respondents indicate very low levels of innovativeness in BEs and only 5.6% indicate VS-VHI in BE.

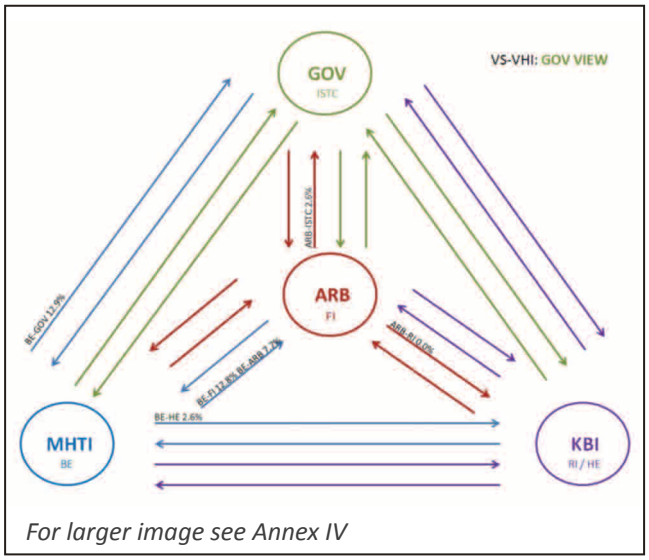
- Surprisingly, GOV Respondents do not have a statistically significant view of GOV's own inter-, intra-linkages and level of innovativeness of BEs. This finding is salient, in comparison with other views, and highly notable as it suggests that GOV has no significant assessment of other Actors' inter-, intra-linkages (see figure 9.14).

[57] This result is significant at the 99.0% confidence level.

[58] This result is significant at the 99.0% confidence level.

[59] This result is significant at the 99.9% confidence level.

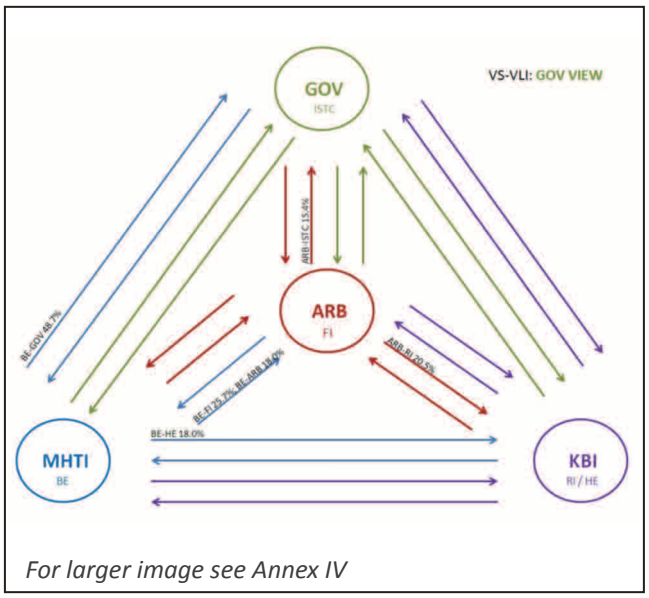
***Figure 9.14** – Government View of Linkages and Level of Innovativeness – VS-VHI*




*For larger image see Annex IV*

The policy implications point to: (i) Government not having at-hand means and instruments to map and measure the GNSI for policy assessment, monitoring, evaluation and adjustment despite extant policy documents on STI; (ii) the extent to which Government is, itself, isolated from the GNSI (see Figure 9.3), regarding Government inter-linkages which are deemed very strong only with HE (a traditional link) and very weak with all other Actors and none with ARB as assessed by ALL Respondents presents a serious challenge to Government efforts in creating a higher performance NSI even if significant funding becomes available in the near future[60]; (iii) Government not having at-hand means to map and measure the level of innovativeness systemically in the national economy[61]. This is confirmed by Ghana's rankings in the Global Information Technology Report 2012 (World Economic Forum, 2012, p.221) in which the range of positions of Ghana in various categories of the networked readiness index (crucial to stocks and flows of DISK) related to ICT and NSI, is 63rd to 114th out of 142 countries. At the granular level of scrutiny, this performance regarding ICT and networked readiness shows a range of positions of 104th to 122nd out of 142 countries. While the affordability of ICT may rank Ghana relatively competitive at 20th, 65th and 84th out of 142 for mobile tariffs, ICT competition and broadband Internet tariffs, in terms of connectivity, these neither produce externalities that translate into advantages that benefit the GNSI[62], nor generate directly innovativeness in BE; (iv) the Government's ability to manage the conflictual/co-operative balance between Actors, institutions and organisations regarding competition for resources in favour of co-operation is at best tentative, and at worst doubtful; (v) innovation policy coordination is also subject to higher levels of uncertainty than would be otherwise with the availability of comprehensive 'road maps' of the GNSI; (vi) achieving convergence in innovativeness with other frontier, or potential, EMEs is likely to be extremely difficult; (vii) the Government's ability to orchestrate the strategic coherence of the GNSI is vague; and, (viii) the Government tends to perceive its role as a recipient of resource solicitations, and Government outreach is limited.

***Figure 9.15** – Government View of Linkages and Level of Innovativeness – VS-VLI*




*For larger image see Annex IV*

- Notably, 48.7% of GOV Respondents indicate very strong linkages between BE-GOV and a very low level of innovativeness of BE. Additionally, 15.4% of GOV Respondents indicate ARB-ISTC VS-VLI. However, GOV Respondents do not have a statistically significant view on KBI-GOV (HE-GOV or RI-GOV) linkages or on GOV-KBI (GOV-HE or GOV-RI) linkages (see Figure 9.15 above).

- More than 89.9% of MHTI, 95.6% of KBI, and 83.4% of ARB Respondents indicate very low level of innovativeness of BE regardless of the strengths (or weaknesses) Government linkages, respectively[63].

- 18.4%-40.0% of MHTI Respondents view GOV linkages

[60] Ghana as a new oil exporter is expected to harvest substantial revenues (see Asamoah, J., 2011. Strategic Resources and their Management: the Oil Find in Ghana; Aaronson, S.A., 2011. How Empowering Ghanaians Can help Ghana Avoid an Oily Mess; Koria, R. and Koszegi, S., 2011. National Systems of Innovation (NSI): Measurement and Implications for Science, Technology and Innovation Policy in Ghana; in: UNIDO (United Nations Industrial Development Organization), *Conference on Competitiveness and Diversification: Strategic Challenges in a Petroleum Rich Economy.* Accra, Ghana 14-15 March 2011. According to Thorvaldur Gylfason, Professor of Economics, University of Iceland, Ghana can expect nominal oil and gas revenues of US$9 Billion annually from 2013 and between UDS18 to 36 Billion annually from 2018, See "Oil-Spill Economics: How Ghana can Succeed", VOX, 23/March/2011,www.voxeu.org

[61] Notwithstanding the availability of indicators such as those found in: i) AU-NEPAD (2010), African Innovation Outlook; and ii) The World Bank (2012), World Development Indicators.

[62] It is telling that in conducting the GNSI survey a noticeable number of Respondents (GOV, KBI, MHTI, ARB) had e-mails served by Microsoft (Hotmail), Google (Gmail), Yahoo! (Yahoo! mail) rather than .gh, .gov, .ac, .com (attached to Ghana).

[63] This result is significant at the 99.0% confidence level.

with other actors (and itself) as VS-VLI (see Figure 9.17). In contrast, 50.0%-71.7% view GOV linkages as VW-VLI. 36.6% to 48.2% of KBI indicate that GOV linkages with other Actors (and itself) as VS-VLI (see Figure 9.19), while 47.4% to 59.0% of KBIs indicate GOV linkages as VW-VLI. 66.7% of ARB indicate that GOV linkages with itself (ISTC) as VS-VLI (see Figure 9.20 below), while 16.7% indicate view GOV linkages as VW-VLI.

The key policy implications group into: (i) lack of instrumentation to monitor level and rate of innovativeness; (ii) under-leveraged legislative power; (iii) muted policy dialogue; and, (iv) competitive divergence below potential frontier EMEs.

Specifically, the statistically significant assessment of very low levels of innovativeness, irrespective of the strengths of Government inter-linkages implies that: (i) the Government command over the environment for innovation is insufficient to foster rapidly, through policy regulation and performance requirements, threshold levels of innovativeness by other Actors; (ii) the Government may not be leveraging its legislative power sufficiently to increase the level of higher-resolution standards in the supply-side for the provision of goods and services[64]; (iii) the policy environment may be insufficiently calibrated by the Government to encourage higher levels of innovativeness systemically; (iv) the role of Government, as the prime driver of the economy[65], is not fully utilised in encouraging innovativeness and innovation among early adopters and early majority in the diffusion of innovation paradigm, through Government procurement modalities, legislation and regulation; (v) the very weak Government linkages at best mutes, and at worst disables, the policy dialogue between GNSI Actors; and, (vi) GOV-BE links are neither resulting in high innovation, nor is Government contributing significantly to the innovativeness of BEs.

The policy recommendations to address these threats to the GNSI are: (i) the SETIRC along with the GNSIPU to strategise and prioritise a MHTI-centred innovation system by legislatively allocating 2% of GDP for public expenditure support to the science and technology sector[66], which can leverage private sector efforts; (ii) ensure that the public sector science and technology base (represented by RIs) is not divorced from MHTI R&D by requiring KBIs (RIs) to instigate fora of dialogue on R&D agendas with MHTI, and Industry Associations and involving Government; (iii) adoption of the UNIDO methodology for surveying NSI for longitudinal monitoring, assessment and evaluation of the GNSI regarding policy implementation, as well as measuring the 'fitness' of GNSI Actors with a view to applying incentives to improve fitness; and, (iv) the GNSIPU to streamline the regulatory environment for STEMIT by auditing regulations to identify and remove burdensome legislation, and to propose new regulations that accelerate innovativeness and innovation in the economy[67].

**Survey Analysis:** Government has no significant assessment of other Actor linkages within the GNSI.

**Policy Implication:** Lack of policy mapping of GNSI for policy monitoring and evaluation.

**Policy Recommendation:** Adoption of UNIDO methodology for surveying NSI for longitudinal monitoring, assessment and evaluation of the GNSI.

#### 9.5.4.2 Business Enterprises [MHTI] Inter-, Intra-Linkages – Level of Innovativeness of Business Enterprises

- Regarding BE intra-, inter-linkages and the level of innovativeness of BE, over 91.8% of ALL Respondents indicate very low innovativeness in BE irrespective of the strengths of BE intra-, inter-linkages. In stark contrast, only 3.4%-5.5% ALL Actors indicate very strong BE linkages with other Actors and very high level of innovativeness of BE.

- Notably, while 48.7% of GOV Respondents indicate very strong linkages between BE-GOV and a very low level of innovativeness in BE (see Figure 9.15 above), this view is contrasted by MHTI Respondents, of which only 23.4% indicate very strong linkages between GOV-BE and a very low level of innovativeness in BE (see Figures 9.16 and 9.17 below).

- 18.0%-48.7% of GOV Respondents view BE linkages as VS-VLI (see Figure 9.15 above). In contrast, 11.7%-18.4% of MHTI Respondents view BE linkages as VS-VLI. 21.1%-37.2% of KBI Respondents indicate that BE linkages as VS-VLI (see Figure 9.19 below), while 58.2%-74.5% indicate view BE linkages as VW-VLI.

- While 48.7% of GOV Respondents and 37.2% of KBI Respondents gauge BE-GOV as VS-VLI, with reference to industry only 18.4%, and 11.7%, MHTI Respondents respectively perceive BE-HE, BE-RI as VS-VLI, and 15.0% perceive RI-BE as VS-VLI (see Figure 9.17).

Policy implications of VW-VLI regarding Business Enterprise inter- and intra-linkages and very low level of innovativeness in Business Enterprise are of particular concern as innovation is manifest mostly in industries (supply-side) and markets (demand-side). Policy implications include: (i) given Business Enterprise isolation from other Actors in the GNSI, especially from Government and ARB, MHTI has little, if any, access to sources of innovation other than its own research and development expenditure and efforts[68] [69]; (ii) reciprocating relations with KBIs are also limited hence the exposure of

[64] A very notable exception is to be found in the UNIDO Ghana National Quality Infrastructure Project that aims to equip the Ghana national standards board with the capacity and capability to comply with national, regional and internal standards with respect to SQAM (food, exports, etc.,).

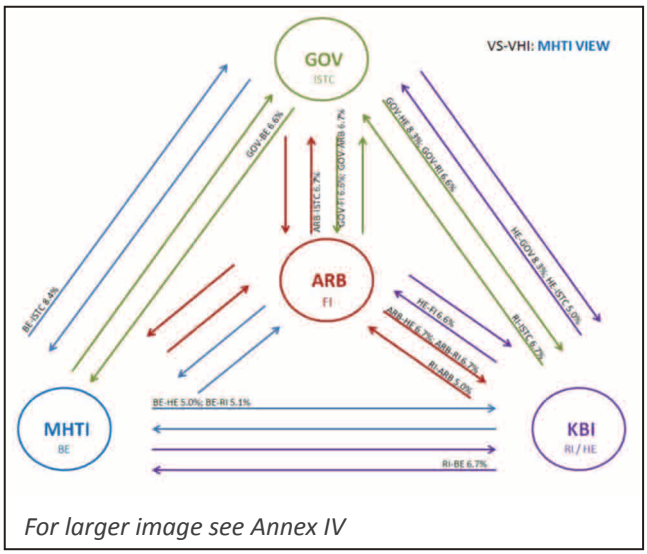
[65] It is to be recognised that in the OECD countries, over the long-term, GOV is directly responsible for between 20% to 65% of respective GDP (1995). Nowadays it is 30% to 55% (http://www.oecd-ilibrary.org/sites).

[66] According to the World Bank (2007 database) expenditure on R&D both public and private amounts to 0.23% of GDP for Ghana. The national STI policy 2010 indicates an intention to allocate a minimum 1% of GDP for the science and technology sector. According to the Legatum Institute (2011) R&D expenditure is 0.4% of GDP (http://www.prosperity.com/country.aspx?id=GH)

[67] For example legislation that provides special treatment (accounting, fiscal) for R&D goods and services that are sourced in response to public procurement tenders.

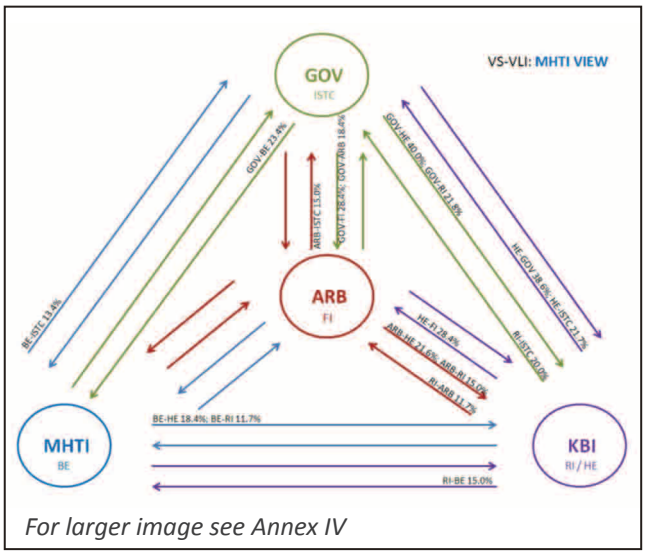
[68] This effort is itself is relatively meager. According to UNCTAD (2011) R&D expenditure is less than 1.5% of GDP.

***Figure 9.16*** *– Medium and High-Tech Industry View of Linkages and Level of Innovativeness – VS-VHI)*




*For larger image see Annex IV*

***Figure 9.17*** *– Medium and High-Tech Industry View of Linkages and Level of Innovativeness – VS-VLI)*




*For larger image see Annex IV*

Business Enterprises to DISK is reduced; (iii) the VW-VLI deficiency should be viewed through the lens of Government's partial and uneven command over the environment for innovativeness and innovation, which in turn implies that the regulatory dynamic for increasing standards and competition is lethargic; (iv) opportunities to leverage and synergise Business Enterprise R&D with that in RIs are severely limited, despite extant Government incentives to Business Enterprises and grants to RIs; (v) the identification of 'promising local companies' and potential 'national champions' is obscured; (vi) market signals with respect to demand are likely to remain unnoticed; and, (vii) opportunities for generating externalities through cross-cutting licensing and patenting, and concomitant fees are limited.

[69] According to the African Innovation Outlook (2010), business enterprise R&D is 4.9% of Gross Domestic Expenditure on Research and Development (GDERD) (US$120.1 Million PPP). See AU–NEPAD, 2010. African Innovation Outlook 2010. Pretoria: AU-NEPAD.

The policy recommendations to address very weak Business Enterprise linkages and very low level of Business Enterprise innovativeness are: (i) consider a preferential tax rate for MHTI as a function of triangular (MHTI-KBIs-ARB) R&D, joint product development, sub-contracting relations; (ii) address the barriers to innovation identified in this Report by MHTI; (iii) initiate under the SETIRC a programme of identifying SMEs that are 'promising local companies' in MHTI and assisting them to grow[70]; (iv) initiate under the SETIRC a 'commercialisation and marketing framework' in tandem with the promising local companies programme that incubates spin-offs and SMEs in MHTI; (v) configure, as part of the Government venture capital system, a Technology Commercialisation Fund (TCF) access to which requires triangulation (MHTI-KBI-ARBs) to enable R&D to become IPRs that can be licensed; and, (vi) perform an analysis of FDI spillovers to MHTI and adjust the FDI regime to enhance spillovers and externalities.

**Survey Analysis:** Very weak inter- intra-BE linkages and low level of BE innovativeness.

**Policy Implication:** Innovation is primarily manifest in industry (supply-side) and markets (demand-side), however BE isolation means little access to other sources of knowledge.

**Policy Recommendation:** Address barriers to innovation and initiate a Promising Local Companies in MHTI programme.

#### 9.5.4.3 Higher Education [KBI] Inter-, Intra-Linkages - Level of Innovativeness of Business Enterprises

- In the case of HE linkages, irrespective of the strengths (or weaknesses) of Higher Education linkages more than 91.6% of ALL Respondents indicate very low levels of innovativeness of BE. Nevertheless, 3.5%-7.3% of Respondents indicate very strong HE inter-, intra-linkages and very high levels of innovativeness of BE[71].

- Specifically, with respect to the key linkages between HE and BE 91.8% of all Respondents indicate very low levels of innovativeness of BE, and only 4% indicate very strong HE-BE linkages and very high levels of innovativeness of BE.

- This is reinforced by 89.9%-91.9% of MHTI Respondents indicating that, irrespective of the strengths of HE inter- and intra-linkages, there are very low levels of innovativeness of BE. 5.0%-8.3% of MHTI Respondents indicate very strong HE inter- and intra-linkages and very high levels of innovativeness of BE (see Figure 9.16).

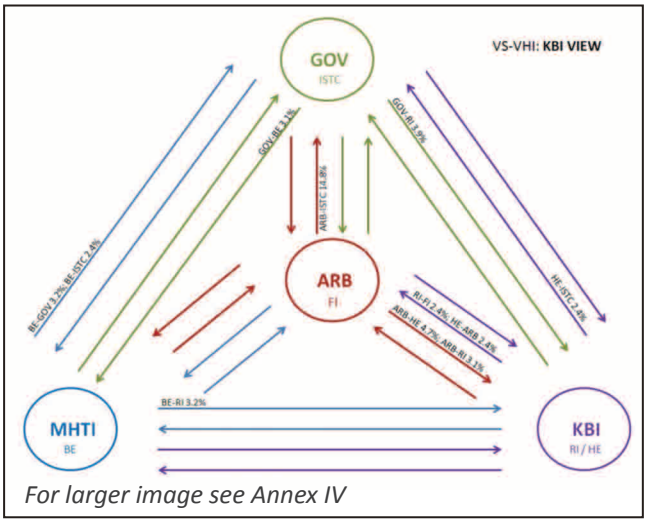
- In the case of HE inter- and intra-linkages specifically with ISTC and ARB, 95.3% and 98.3% of KBI respectively indicate very low levels of innovativeness in BE. With respect to ARB and ISTC only 2.4% and 2.4% of KBI

[70] Setting up an agency for SMEs that are promising local companies in MHTI; setting eligibility criteria; developing programme (firm analysis, follow-up by relevant extant agencies, packaging financial, fiscal, incentive schemes) for the firms to grow.

[71] This result is significant at the 99.0% confidence level.

indicate very strong HE inter-linkages with ARB and ISTC, and very high levels of innovativeness of BE (see Figure 9.18).

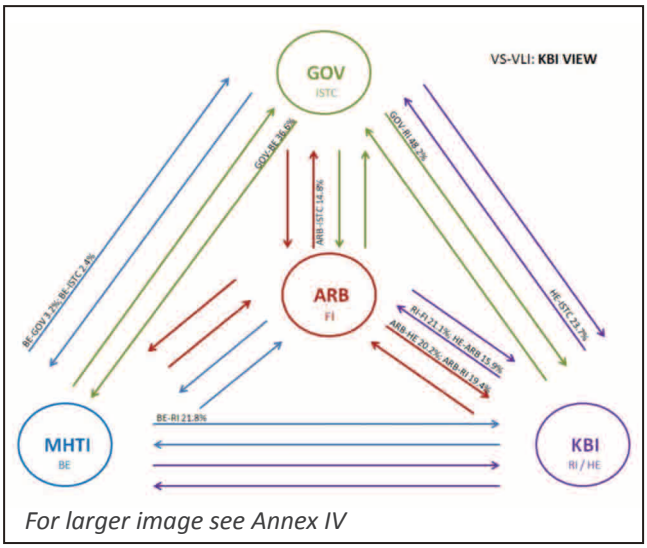
***Figure 9.18** – Knowledge-Based Institution View of Linkages and Level of Innovativeness – VS-VHI)*




*For larger image see Annex IV*

- Notably, GOV Respondents do not have a significant view of HE intra-, and inter-linkages and level of innovativeness of BE. Additionally, with respect to perceptions of KBIs regarding HE-ARB 15.9% indicate VS-VLI. With respect to perceptions of KBI regarding ARB-HE, 20.2% indicate VS-VLI (see Figure 9.19).

***Figure 9.19** – Knowledge-Based Institution View of Linkages and Level of Innovativeness – VS-VLI)*




*For larger image see Annex IV*

- 21.7%-43.3% of MHTI Respondents view HE linkages as VS-VLI. In contrast, 53.3%-68.4% view HE linkages as VW-VLI. 15.9%-23.7% of KBIs indicate HE linkages as VS-VLI (see Figure 9.19), while 71.6%-79.4% of KBIs indicate HE linkages as VW-VLI.

As with GOV inter-, and intra-linkages and the level of Innovativeness of BE, Higher Education inter-, and intra-linkages assessed as very weak concomitant with very low level of innovativeness of BE has serious policy implications. Specifically, these concern: (i) the very weak Higher Education inter-linkages with ARB, FI, ISTC, BE, which imply that KBI DISK do not have outlets, through intermediation and commercialisation, to demand markets; (ii) KBI (Higher Education) have relatively poor market intelligence capacity and capability – in other words they do not really know what MHTI (BEs) and the market need and, as such, can neither respond to, nor address sufficiently, those needs through innovative solutions; (iii) the management of the KBI IPRs system, such as it is, is likely to be remote from users [MHTI (BEs)] and intermediators [ARB (FI)]; (iv) curricula redesign with an increased emphasis on industrial placements is likely to be hampered; (v) research is likely to be tangential to the needs of MHTI; (vi) opportunities for industry funded and sponsored R&D, as well as product development, leading to incubation of spin-offs (in high technology) into SMEs are truncated; and, (vii) opportunities for fund raising are limited.

The policy recommendations to address the very weak Higher Education linkages and very low levels of innovation are: (i) adopt a competitively incentivised IPR management system for KBIs that disproportionately rewards KBIs with the highest STEMIT IPR performance (LPRs and industrial contracts); (ii) recalibrate funding of post-graduate studies to favour R&D in STEMIT programmes; (iii) provide incentives for STEMIT post-graduates to work in the private sector[72]; (iv) redesign STEMIT post-graduates courses and programmes to require one-year placement in an MHTI firm, where part of the research is performed; (v) reconfiguration of the public service entrance and promotion examinations system to link to STEMIT and management courses and programmes in KBIs; and, (vi) incentivise MHTI to write off against profits industry funded and sponsored R&D that takes place under contract in KBIs.

**Survey Analysis:** HE inter- intra-linkages are very weak and the level of innovativeness of BE is very low.

**Policy Implication:** KBIs have highly restricted outlets through intermediation and commercialisation, to demand markets; poor market intelligence; and are insufficiently aware of market needs.

**Policy Recommendation:** Incentivise mobility between KBIs and MHTI and fund KBIs on IPRs performance.

#### 9.5.4.4 Research Institutes [KBI] Inter-, Intra-Linkages – Level of Innovativeness of Business Enterprises

- With respect to RI inter-, intra-linkages, more than 91.8% of ALL Respondents indicate very low levels of innovativeness of BE irrespective of the strength or weaknesses of linkages. This is reinforced by MHTI and KBI of whom more than 89.9% and 95.6%, respectively,

[72] Through mechanisms that encourage self-employment by 'two years plus one' funding for STEMIT masters and 'three years plus two' funding for STEMIT doctorates to use their R&D studies to create businesses. Also via mechanisms that incentivise MHTI to hire STEMIT post-graduates.

indicate very low levels of innovativeness of BE irrespective of the strength or weakness of RI linkages. In contrast, only 3.0%-7.3% of ALL Respondents, and 5.0%-6.7% of MHTI Respondents, indicate very strong RI linkages and very high levels of innovativeness of BE.

- Notably, while an encouraging 48.2% of KBIs indicate very strong linkages between GOV-RI and a very low level of innovativeness of BEs (see Figure 9.19 above), this view is contrasted by MHTI of which only 11.7% indicate VS-VLI with respect to BE-RI, and a very low level of innovativeness in BEs, and 15.0% of MHTI indicate RI-BE linkages as VS-VLI (see Figure 9.17 above).

- While Government Respondents do not have a significant view on RI linkages and the level of innovativeness of BEs, 69.9%-78.3% of MHTI Respondents view RI linkages as VW-VLI. 21.1% of KBIs indicate RI linkages as VS-VLI (see Figure 9.19 above), while 74.5% indicate the linkages as VW-VLI. 16.7% of ARBs indicate that RI linkages as VW-VHI, while 83.4% indicate the linkages as VW-VLI.

- Notably, only 2.4% of KBIs indicate very strong RI linkages and very high levels of innovation of BEs (see Figure 9.18 above). With respect to the key linkage between RIs and BEs, 92.0% of ALL Actors indicate very low levels of innovativeness of BEs, and only 3.8% indicate very strong linkages and very high levels of innovation of BEs.

The policy implications of VW-VLI with respect to Research Institutes inter-linkages are particularly serious as Research Institutes constitute a key transmission mechanism for DISK in terms of IPRs into best practice and the market place. Policy implications are similar to those concerning HE, but nuanced by what should be a feed role and Research Institutes isolation from other GNSI Actors (except with HE and GOV): (i) the policy analysis points to at best a solitary role, and at worst a dysfunctional role, of Research Institutes in the GNSI; (ii) Research Institute (strategic) research and development may be divergent from the needs of MHTI; (iii) even if Research Institutes DISK transmission mechanisms have potential, the almost complete isolation of ARB from the GNSI implies truncation as the financial framework for commercialisation is missing to a large extent (see Figures 9.7, 9.8 and 9.12 above for the RIs' isolation and missing bi-directional inter-linkages between ARB-KBI (vice versa) and ARB-MHTI); (iv) inter-linkages are VW-VLI implies absence of a sales and marketing disposition on the part of Research Institutes with respect to IPRs, BEs and MHTI; (v) as with HE, opportunities for funding, sponsorship and R&D joint ventures with MHTI (intermediated by ARB) are severely limited; (vi) opportunities for human capital mobility between Research Institutes and MHTI are truncated; and, (vii) the research agendas of Research Institutes is likely to be divergent from the demands of the market place.

The policy recommendations for overcoming very weak Research Institute inter-linkages and low levels of innovativeness of BE are convergent with those for HE and include: (i) in addition to the national auditing of Research Institutes, submit Research Institutes to external international review by bodies such as UNIDO, OECD, and South Africa's National Advisory Council on Innovation (NACI); (ii) recalibrate Research Institute human resources policy, terms and conditions to enable Research Institute staff to perform their research in MHTI companies in terms of sabbaticals, contracts or under patents, licenses and royalty protocols; (iii) reconfigure Government procurement of services from Research Institutes to require triangulation by Research Institutes (i.e. RI-MHTI-ARB) in the provision of services; and (iv) reconfigure Government funding support to Research Institutes to be contingent on matching funds to that raised by Research Institutes from MHTI in the form of sponsorships.

**Survey Analysis:** Isolated or dysfunctional role of RIs in GNSI.

**Policy Implication:** Strategic research and development operations misaligned with the needs of MHTI specifically and that of the market in general.

**Policy Recommendation:** Reconfigure government procurement of services from RI to require triangulation (RIs–MHTI–ARBs).

#### 9.5.4.5 Arbitrageurs Intra-, Inter-Linkages – Level of Innovativeness of Business Enterprises

- Regarding ARB intra-, inter-linkages and level of innovativeness of BEs, irrespective of the strength of linkages, over 91.9% of ALL Respondents indicate very low level of innovativeness in BEs. In contrast only 3.3%-4.7% indicate very strong ARB linkages with other Actors and very high level of innovativeness of BEs.

- The assessment by Government Respondents is that 15.4% perceive the linkages between ARB-ISTC (GOV) as VS-VLI. Additionally, with respect to KBIs assessment regarding HE-ARB and RI-FI, respectively, 15.9% and 21.1% KBIs indicate VS-VLI. With respect to KBIs assessment of ARB-HE and ARB-RI linkages, respectively, 20.2% and 19.4% indicate VS-VLI (see figure 9.19 above).

- 15.0%-21.6% of MHTI Respondents estimate ARB linkages as VS-VLI (see Figure 9.17). In contrast 68.4%-75.1% rate the linkages as VW-VLI. 14.8%-20.2% of KBI Respondents indicate ARB linkages as VS-VLI, while 75.3%-80.7% assess the linkages as VW-VLI.

- With respect to ARB-HE and ARB-RI linkages, Industry, Government and KBI have a similar perspective. However, there is no assessment of ARB-BE link, which is significant.

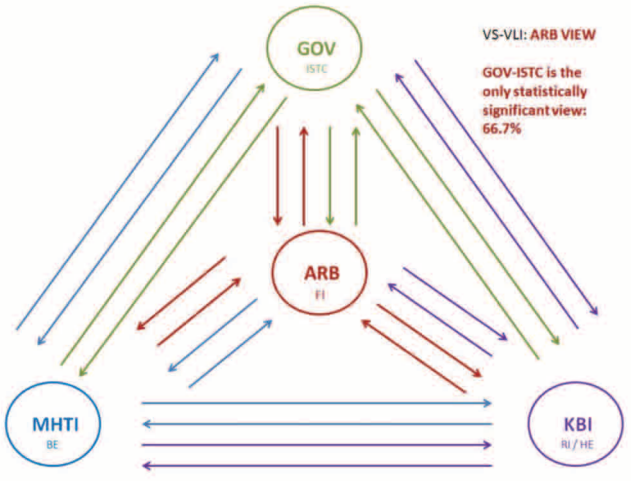
Policy implications of VW-VLI with respect to Arbitrageur inter-, and intra-linkages and level of innovativeness in BE given Arbitrageur isolation include: (i) truncated efforts by Arbitrageurs to intermediate DISK from KBI to MHTI and BE, and therefore stocks of knowledge remain unexposed while any flows are, at best, glacial, and at worst non-existent; (ii) very weak GOV-ARB inter-linkages imply limited ability of Arbitrageurs to influence innovation policy with respect to KBI and MHTI; (iii) Arbitrageurs are, by and large, unable to exploit the competitive advantages that arise from information asymmetries extant between KBIs and other Actors to generate externalities; (iv) Arbitrageurs are largely cut off from taking equity positions in either potential start-up

businesses, based either on KBI R&D outputs or spin-offs from KBI and MHTI; and, (v) the crucial role of linking the GOV-KBI and KBI-MHTI axes of the Triple Helix type 4 is largely missing.

The policy recommendations regarding Arbitrageur inter-linkages and very low level of innovativeness are: (i) to decide a strategy for expanding the size of the capital and financial market in Ghana in terms of number of firms, as well as the availability of Venture Capital[73]; (ii) condition fiscal and monetary, as well as regulatory and performance incentives to the finance capital industry on the intermediation role of Arbitrageurs, with respect to KBIs and MHTI; (iii) use Government-Backed Venture Capital to match equity positions by Arbitrageurs in technology incubation programmes in KBIs; (iv) require KBI development of science and technology parks to have 'anchor' tenants from finance capital industry; (v) use the STEMIT Human Capital Mobility Fund to support mobility of personnel in finance capital to teach in KBIs (sabbaticals) with respect to Venture Capital management of R&D and commercialisation; (vi) map the structure of early stage financing of innovation and entrepreneurship[74] in Ghana; (vii) restructure Government-Backed Venture Capital into separate funds relevant to stages of innovation and entrepreneurship to induce the finance capital industry to enhance their intermediation; (viii) increase competition in the finance capital industry by adjusting fiscal conditions to enable high net worth individuals to invest directly in start-ups or in venture capital funds.

There is no reading on ARB-BE link, which is significant (see Figures 9.20).

***Figure 9.20** – Arbitrageur View of Linkages and Level of Innovativeness – VS-VLI)*




*For larger image see Annex IV*

[73] The exemplary Venture Capital Industry (VCI) is that of Israel notably the Yozma programme that created the VCI in Israel. The policy addressed the failures in the process of innovation and entrepreneurship (early stages funding gaps, absent complementary assets and skills). See Avnimelech, G. and Teubal, M., 2005. Evolutionary Innovation and High Tech Policies: What Can We Learn from the Israel's Targeting of Venture Capital? *Science, Technology and Economic Program (SETE)*, Working Paper Series WP-25-2005. Neaman Institute, Technion-Israel Institute of Technology.

[74] Latent stage (seed capital), early stage ('angel' investors), growth (corporate/private equity).

**Survey Analysis:** Arbitrageurs (Financial Institutions) and venture capital are detached from other Actors in the GNSI.

**Policy Implication:** Stocks of knowledge are unexposed and flows of DISK are glacial at best and nonexistent at worst.

**Policy Recommendation:** Condition incentives to finance capital industry on the intermediation role of ARB.

The presence of statically significant values for linkages between Actors is a clear indication that the Respondents do perceive systematic relationships between the two variables Actor linkages and level of innovativeness in BE.

The mapping and measurement of GNSI Actor linkages with the production system in the economy, the importance of Actor and strength of inter-, intra-Actor linkages, and strength of linkages and level of innovativeness of BE (from Actor perspective of other Actor's linkages and Actor's own perspective of own linkages with others) shows, in general: (i) perforated linkages with the system of production, (ii) recognition of Actor importance but overall poorly articulated inter-Actor linkages; and (iii) specifically very low levels of innovativeness and innovation in BE.

We move on to identify the factors that constitute the barriers to innovation and are responsible for the perforated, and poorly articulated linkages, as well as the palpable lack of richness in the environment for innovativeness and innovation.

### 9.5.5 Latent Factors to Barriers to Innovation

Factor analysis (to indicate the underlying factors that influence significantly barriers to, and hence policy instruments for, innovation) enables evidence-based policy design to be targeted specifically to remove the highest barriers to innovation in prioritised sequencing.

Factor analysis condenses observed variables into factors in a pattern matrix (clusters of inter-correlated variables) with 'mutual interdependence' (Gaur, 1997). The factors represent the underlying structure that is responsible for the variation of variables in the data and thus the population (Kim and Mueller 1978). Tables 9.7, 9.8, 9.10 and 9.13 below indicate the underlying factors of barriers to innovation.

#### 9.5.5.1 Description of Table Structure

The column factor number indicates the descending rank order of the importance of the factor, which influences the sets of barriers to innovation variables. The column factor name provides a description for the grouped variables influenced by the factor, and enables meaningful policy discussion of the barriers to innovation. The factor names are assigned based on the factor loading of the variables taking the higher loading variables into consideration as well as judicious use of empirical evidence and theory in the literature of NSI. The naming of factors therefore reflects the variables that are most influenced by the underlying factor, and hence there are commonalities and differences regarding Actor responses. The column factor loading indicates the

correlation between factors and variables, i.e. the extent to which the factor influences the variable. The column Cronbach's Alpha indicates the internal consistency and reliability of the factor, and hence the cohesion of variables as a group. The dominant heuristic, or commonly accepted rule of thumb, for describing internal consistency and reliability using Cronbach's Alpha, is indicated in Table 9.6 (George and Mallery, 2003; Kline, 1999; Cortina, 1993).

***Table 9.6** – Internal Consistency of Factor*

| Cronbach's Alpha | Internal Consistency/Reliability |
|---|---|
| a ≥ 0.9 | Excellent |
| 0.9 > a ≥ 0.8 | Good |
| 0.8 > a ≥ 0.7 | Acceptable |
| 0.7 > a ≥ 0.6 | Questionable |
| 0.6 > a ≥ 0.5 | Poor |
| 0.5 > a | Unacceptable |

For the purpose of policy analysis, factors influencing groups of variables with Cronbach's Alpha below 0.7 are deemed inconsistent and unreliable and are rejected for policy purposes. The factors enable economy-wide policy prescriptions, as well as Actor (sector) specific policy prescriptions.

The column Total Variance Explained (TVE) indicates the amount of variance (variation) of the groups of variables, in the data sample and population, which is accounted for by the factor. It is an indication of the extent or power of the influence of the factor. The column Kaiser-Meyer-Olkin (KMO) is a measure of sampling adequacy. It indicates the robustness of the sample in terms of distinct and reliable factors extracted. The Bartlett's Test of Sphericity (BTS) indicates the significant confidence level regarding the coherence of factors, reproducibility and generalisability of the results[75] (Kaiser, 1974; Dziuban and Shirkey, 1974, p.359; Kim and Mueller 1978, p.54; Rummel, 1970).

#### 9.5.5.2 Latent Factors to Barriers to Innovation – ALL

***Table 9.7** – Latent Factors to Barriers to Innovation (ALL)*

| All Respondents (ALL) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Factor Number | Name of Factor | Variables | Factor Loading | Cronbach's Alpha | Total Variance Explained (TVE)% | KMO | Bartlet's Test of Sphericity | | |
| | | | | | | | Chi Squared | Df | Significance |
| 1 | Skills-ITC Capability/ Capacity | • Quality of technically trained manpower<br>• Rate of access to ICT<br>• ICT capacity<br>• Lack of technically trained manpower | 0.797<br>0.785<br>0.760<br>0.695 | 0.833 | 33.524 | 0.817 | 1,625.579 | 136 | 0.000 |
| 2 | Unsophisticated Markets | • Lack of demanding customers<br>• Lack of innovative customers<br>• Lack of competition | 0.892<br>0.839<br>0.682 | 0.752 | 9.671 | | | | |
| 3 | Deficient Fiscal Policy | • Lack of finance<br>• Lack of explicit policy support | 0.770<br>0.737 | 0.598 | 8.437 | | | | |
| 4 | Reduced Organisational Risks | • Excessive perceived economic risk<br>• Organisational rigidities<br>• Hierarchical organisations<br>• Restrictive public/ governmental regulations | -0.809<br>-0.723<br>-0.675<br>-0.653 | 0.757<br>Cumulative Total (CTVE) | 7.037<br>58.669 | | | | |

NB. Residuals are computed between observed and reproduced correlations. There are 68 (50.0%) non-redundant residuals with absolute values greater than 0.05.

In the assessment of ALL Respondents Factor 1 –Skills – ICT Capability/Capacity– is the highest most significant

[75] Arbitrageurs did not produce a factor result as the number of Respondents, while entirely adequate for cross-tabulation, did not meet the statistical requirements necessary to conduct a factor analysis.

barrier to innovation in the GNSI, in which the 'Quality of Technically Trained Manpower' is the most crucial variable.

- Factors 2 <Unsophisticated Markets>, 3 <Deficient Fiscal Policy> and 4 <Reduced Organisational Risks> are also significant barriers to innovation, however individually each explains less than a third of the TVE of Factor 1.

- Factor 1 <Skills-ITC Capability/Capacity> confirms the Triple Helix type 4 configuration of the NSI and indicates the critical importance of talent and the diffuseness of ICT within the system as a conduit for enhancing the stocks and flows of DISK and skills. However, given the perforated linkages identified, it is clear that the GNSI is far from Triple Helix type 4 status and performance.

- Factor 2 <Unsophisticated Markets> demonstrates a consensus with GOV, MHTI Respondents of the importance of markets for driving innovation through demanding customers, innovative customers and competition. This factor is consistent with findings in the literature (Bartels et al., 2012).

Overall, the key policy implication is that without threshold levels in Skills-ICT Capability/Capacity economy-wide innovativeness and innovation is extremely difficult to attain[76]. Specifically policy implications include: (i) in resource constrained circumstances, the crucial choice is where fiscal and monetary incentives, as well as regulation and performance requirements, should be directed to improve the most significant Factor 1 <Skills-ICT Capability/Capacity>, through improving the 'Quality of Technically Trained Manpower' and the 'Rate of Access to ICT'; (ii) in terms of policy implications (and hence the sequencing of policy implementation through business plans and managerial action at the level of Actors) the four factors have different temporal characteristics in terms of policy action (but not necessarily policy outcome)[77]; (iii) F1 <Skills-ICT Capability/Capacity> is relatively short term (1-3 years) given the capacity aspect of ICT; (iv) F2 <Unsophisticated Markets> and F3 <Deficient Fiscal Policy> are medium-term (3-5 years) given the legislative aspect of fiscal policy; (v) F4 <Reduced Organisational Risks> is long term (5-10 years) given the organisational behaviour aspects and the need to change institutional behaviour; and, (vi) all factors are important and have to be addressed by Government policy on innovation.

The aforementioned implications invoke a policy orientation that: (i) in a resource constrained environment, where hard choices and trade-offs must be made, the sequencing of policy targets should be in the rank order (first to last) F1 <Skills-ITC Capability/Capacity>, F2 <Unsophisticated Markets>, F3 <Deficient Fiscal Policy>, F4 <Reduced Organisational Risks>; and, (ii) policy instruments to effect the changes required must be differentiated according to the characteristic of the variables to be changed. F1 <Skills-ITC Capability/Capacity> involves sector specific pedagogic and economy wide infrastructure policy decisions. F2 <Unsophisticated Markets> calls for, over time, a ratcheting up of standards, increasing the number of higher-resolution standards and increasing legislation to increase competition. F3 <Deficient Fiscal Policy> demands legislative measures that can be contested in law in order to enable Actors to change their organisational postures towards other Actors in terms of strengthening inter-linkages and enabling DISK to flow around the GNSI. F4 <Reduced Organisational Risks> calls for policy measures that reduce the transaction costs of doing business and adopting innovations[78].

Looking at each Actor in turn, we find that different Actors assess the factor barriers to innovation differently although there are commonalities.

#### 9.5.5.3 Latent Factors to Barriers to Innovation – Government

- From the perspective of GOV Respondents Factor 1 <Constrained Human Capital Resources> is the highest barrier to innovation in the GNSI, and in this the 'Quality of Technically Trained Manpower' is the most crucial variable.

- The variable 'Quality of Technically Trained Manpower' is consistent with the assessment by ALL Respondents, in that Factor 1 accounts for 63.5% and 76.2% of the variance in this crucial variable, with respect to ALL and GOV Respondents, and thus the sample and population.

- In comparing Factor 1 in GOV and ALL Respondents, we see the factor influencing the variable 'Lack of Technically Trained Manpower'. The point of difference is that whereas Factor 1 (ALL Respondents) is responsible for 48.3% of the variance in this variable, in Factor 1 (GOV Respondents) it is responsible for 69.4%.

[76] With respect to Global Competitiveness Index (GCI), Ghana's ranking across a range of indicators relevant to innovation is: GCI 2010–2011 (out of 139) =114; GCI 2009–2010 (out of 133) = 114; GCI 2008–2009 (out of 134) = 102. Innovation and sophistication factors =100 (Business sophistication = 97; Innovation = 99); Basic requirements = 122 (Institutions = 67; Infrastructure =106; Macroeconomic environment = 136; Health and primary education =122); Efficiency enhancers = 96 (Higher education and training = 108; Goods market efficiency = 75; Labor market efficiency = 93; Financial market development = 60; Technological readiness = 117; Market size = 83). Source: World Economic Forum, 2010. *The Global Competitiveness Report* 2010-2011.

[77] Notwithstanding the electoral cycle, or the time taken for legislative and regulatory processes to place policy on statute via parliamentary fiscal and monetary decisions (white paper, green paper, committee stage, bill and law). It is fully recognised firstly that such temporal characteristics are subject economically to the consequences (time delay, dislocation, discontinuities) of: (i) exogenous shocks; (ii) market failures; and (iii) Government failures. Secondly, policy business plans and managerial actions are expected to be of a 'rolling' nature in order to attain, through incremental advances, as well as accelerated spurts, higher levels of innovativeness and innovation throughout the economy in the long-term.

[78] While Ghana has improved its performance in the World Bank "Doing Business" variables since 2004 much more needs to be done. Scrutiny of Ghana's performance in the 'Doing Business' surveys shows relative decline in the face of absolute improvements from 2004-2012 in: starting a business; dealing with construction permits; getting electricity; registering property; getting credit; paying taxes; trading across boarders (but costs have risen); enforcing contracts; resolving insolvency. No improvement in protecting investors. However, despite these improvements, Ghana's rank position has slipped between 2011 and 2012 in all the above categories except: getting electricity; enforcing contracts and resolving insolvency. With reference to a key variable in innovation, starting a business, Ghana slipped 19 rank positions between 2011 and 2012. See IFC (International Finance Corporation) and World Bank, 2012. Doing Business 2012: Doing Business in a More Transparent World. Economy Profile: Ghana. Washington DC: The World Bank Group.

***Table 9.8** – Latent Factors to Barriers to Innovation (Government)*

| Government Responses (GOV) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Factor Number | Name of Factor | Variables | Factor Loading | Cron-bach's Alpha | Total Variance Explained (TVE)% | KMO | Bartlet's Test of Sphericity | | |
| | | | | | | | Chi Squared | Df | Significance |
| 1 | Constrained Human Capital Resources | • Quality of technically trained manpower<br>• Lack of technically trained manpower<br>• Lack of information (Knowledge gap)<br>• Restrictive public/ governmental regulations | 0.873<br>0.833<br>0.622<br>0.579 | 0.798 | 26.75 | 0.551 | 317.755 | 136 | 0.000 |
| 2 | Unsophisticated Markets | • Lack of demanding customers<br>• Lack of innovative customers | 0.935<br>0.822 | 0.826 | 14.152 | | | | |
| 3 | Organisational Risks | • Excessive perceived economic risk<br>• Organisational rigidities | 0.791<br>0.693 | 0.532 | 10.669 | | | | |
| 4 | Constrained ICT Flows & Stocks | • Rate of access to ICT<br>• ICT capacity<br>• Hierarchical Organisations<br>• Brain drain | -0.809<br>-0.799<br>-0.794<br>-0.651 | 0.818 | 9.028 | | | | |
| 5 | (THIS FACTOR IS NOT RELIABLE AND HENCE NOT NAMED) | • Lack of higher resolution regulations<br>• Lack of competition | 0.684<br>-0.578 | -0.08 | 6.784 | | | | |
| 6 | (THIS FACTOR IS NOT RELIABLE AND HENCE NOT NAMED) | • Lack of finance<br>• Innovations costs (too high) | 0.836<br>0.599 | 0.458<br>Cumula-tive Total (CTVE) | 6.202<br>73.585 | | | | |

NB: Residuals are computed between observed and reproduced correlations. There are 66 (48.0%) non-redundant residuals with absolute values greater than 0.05.

- Factor 2 <Unsophisticated Markets> is the second highest barrier to innovation accounting for 14.152% TVE and influences the policy variables 'Lack of Demanding Customers' and 'Lack of Innovative Customers' accounting for 87.4% and 67.6% of variance in these variables respectively. Again this factor reflects F2 (ALL Respondents).

- Notably, from GOV Respondents' perspective, Factor 3 <Organisational Risks> is the third highest barrier to innovation. The factor accounts for 62.6% and 48.0% of the variance in the respective variables ('Excessive Perceived Economic Risk' and 'Organisational Rigidities').

- Factor 4 <Constrained ICT Flows & Stocks> is also a significant barrier to innovation, however it only accounts for 9.028% of the TVE, and 12.3% of the total cumulative variance explained (CTVE).

- It is notable that the variable 'Lack of explicit policy support' does not load on any factor as a variable. This might suggest that GOV assess that their policy is adequate. However, this perspective is not convergent with the view of MHTI, KBI, and ALL Actors.

- From a perspective of GOV Respondents, variables 'Quality of Technically Trained Manpower' and 'Lack of Technically Trained Manpower' are the most important policy variables.

The key policy implications from factors 1 to 4 reflect those specific to ALL Respondents and include: (i) F1 <Constrained Human Capital Resources> sector specific pedagogic policy decisions to address the 'Quality of Technically Trained Manpower' through recalibrating curricula reform to the needs of MHTI; (ii) F2 <Unsophisticated Markets> increasing the level of standards and 'Standards Setting' to encourage MHTI (BE) to meet higher resolution standards by innovating and adopting new technology; (iii) F3 <Organisational Risks> invokes the policy response of reducing economy-wide transaction costs; and F4 <Constrained ICT Flows & Stocks> requires economy wide infrastructure policy decisions to make available widely Internet broadband capacity so that Ghana can move toward an e-economy, not only with GOV conditioning procurement through electronic filing for example.

More specifically the implications are that: (i) in resource constrained circumstances, given the choice, funds should be directed to improve Skills-ICT Capability and Capacity, through explicit policy support to improving the quality of 'Technically Trained Manpower', and addressing the 'Lack of Technically Trained Manpower'; (ii) increasing the resolution of standards through 'Standard Setting', at higher levels over time, by means of 'Regulation' and 'Government Procurement' terms and conditions would have an impact in making the market more sophisticated and therefore more innovative; (iii) in order for markets to meet the higher standards they are forced to become more adaptive and innovative. However, with reference to 'Availability of Policy Instruments & Success'

– each Respondent Actor in the range 63.3%-74.4% indicates that the policy instruments ('Standards Setting,' 'Regulation' and 'Government Procurement') are not successful (see Table 9.9); (iv) these three particular policy instruments ('Standards Setting,' 'Regulation' and 'Government Procurement') need to be recalibrated and re-configured to better incentivise adaptive behaviour and innovativeness in markets by economic agents; and (v) without adequate human capital, economy-wide innovativeness and innovation is virtually impossible to achieve. The central role of STEMIT in industrialisation, productivity and sustainable economic modernisation is widely acknowledged as the *sine qua non* of socio-economic development and structural change[79].

***Table 9.9** – Success of Selected Policy Instruments*

| | All Actors % | | Government % | | MHTI % | | KBIs % | | Arbitrageurs % | |
|---|---|---|---|---|---|---|---|---|---|---|
| Policy Instrument | VHS | NS | VHS | NS | VHS | NS | VHS | NS | VHS | NS |
| Government Procurement | 29.5 | 70.5 | 30.8 | 69.3 | 31.7 | 68.4 | 28.8 | 71.4 | | |
| Standard Setting | 32.5 | 67.3 | 25.6 | 74.4 | 36.7 | 63.3 | 31.1 | 69.0 | | |
| Regulation | 33.2 | 66.6 | 28.2 | 71.8 | 31.7 | 68.2 | 35.0 | 65.2 | | |

### 9.5.5.4 Latent Factors to Barriers to Innovation – Medium-High Tech Industry

***Table 9.10** – Latent Factors to Barriers to Innovation (Medium and High-Tech Industry)*

| Industry Respondents (MHTI) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Factor Number | Name of Factor | Variables | Factor Loading | Cron-bach's Alpha | Total Variance Explained (TVE)% | KMO | Bartlet's Test of Sphericity | | |
| | | | | | | | Chi Squared | Df | Significance |
| 1 | Organisational Risks | • Excessive perceived economic risk<br>• Heirarchical organisations<br>• Organisational rigidities | 0.794<br>0.670<br>0.608 | 0.821 | 40.52 | 0.744 | 633.823 | 136 | 0.000 |
| 2 | Deficient Fiscal Policy | • Lack of explicit policy support<br>• Lack of finance<br>• Innovation costs (too high)* | 0.857<br>0.765<br>0.694 | 0.765 | 10.759 | | | | |
| 3 | Unsophisticated Markets | • Lack of demanding customers<br>• Lack of innovative customers<br>• Lack of competition<br>• Brain drain | 0.909<br>0.827<br>0.595<br>0.578 | 0.764 | 8.988 | | | | |
| 4 | ICT Skills Incapacity/ Incapability | • Rate of access to ICT<br>• Quality of technically trained manpower<br>• ICT capacity<br>• Lack of technically trained manpower | -0.854<br>-0776<br>-0.752<br>-0.702 | 0.852<br>Cumula-tive Total (CTVE) | 8.432<br>68.699 | | | | |

NB: Residuals are computed between observed and reproduced correlations. There are 71 (52.0%) non-redundant residuals with absolute values greater than 0.05.

- From the perspective of MHTI Respondents Factor 1 <Organisational Risks> is the highest barrier to innovation in the GNSI, in which the 'Excessive Perceived Economic Risk' is the most crucial variable. Factor 1 accounts for 40.52% of TVE. This is the highest TVE across Actors. The variable 'Excessive Perceived Economic Risk' in Factor 1 accounts for 63.0% of the variance in the variable, and thus in the sample and population.

- Factor 2 <Deficient Fiscal Policy> is the second highest barrier to innovation accounting for 10.759% TVE; influences the policy variables 'Lack of Explicit Policy Support', 'Lack of Finance' and 'Innovation Costs (too high)'; and accounts for 73.4%, 58.5% and 48.2% of variance in these variables, respectively.

- Factor 3 <Unsophisticated Markets> is the third highest barrier to innovation accounting for 8.988% TVE; influences the policy variables 'Lack of Demanding Customers' and 'Lack of Innovative Customers', additionally 'Lack of Competition' and 'Brain Drain' and accounts for 82.6%, 68.4%, 35.4% and 33.4% of variance in these variables, respectively. The

[79] Ju *et al* (2011)

***Table 9.11** – Ghana's Networked Readiness*

| Network Readiness Index 2012 | Rank (out of 142)<br>97 | Score (1-7)<br>3.4 |
|---|---|---|
| A. Environmental Subindex | 63 | 3.9 |
| 1st Pillar: Political & Regulatory Environment | 55 | 3.9 |
| 2nd Pillar: Business & Innovation Environment | 82 | 3.9 |
| B. Readiness Subindex | 99 | 4.0 |
| 3rd Pillar: Infrastructure & Digital Content | 124 | 2.6 |
| 4th Pillar: Affordability | 46 | 5.6 |
| 5th Pillar: Skills | 112 | 3.8 |
| C. Usage Subindex | 114 | 2.9 |
| 6th Pillar: Individual Usage | 116 | 2.0 |
| 7th Pillar: Business Usage | 99 | 3.2 |
| 8th Pillar: Government Usage | 109 | 3.3 |
| D. Impact Subindex | 100 | 3.0 |
| 9th Pillar: Economic Impacts | 88 | 3.0 |
| 10th Pillar: Social Impacts | 111 | 3.0 |

presence of two additional variables as compared to Factor 2 for GOV, namely 'Lack of Competition' and 'Brain Drain' adds an additional dimension to the barrier from the perspective of MHTI, however they are not as important as the 'Lack of Demanding Customers' and 'Lack of Innovative Customers'. These two additional variables are important in that the brain drain that sub-Saharan Africa experiences annually represents a socio-economic class of the population made up of the innovators, early adopters and early majority, and who are overwhelmingly professionals, technicians and the highly skilled (and in demand in advanced industrialised countries)[80]. The 'Brain Drain' is directly related to 'Lack of Competition' through the absence of a professionally demanding group of the population (socio-economic classes A, B)[81].

- With reference to the Actor-centric view (see Figures 9.12 and 9.13 above) even though GOV and MHTI do not have any statistically significant linkage in terms of importance of Actor and strength of linkage, the factor analysis indicates a convergent assessment with respect to <Unsophisticated Markets> as a high barrier to innovation.
- Factor 4 <ICT-Skills Incapacity/Incapability> is also a significant barrier to innovation in the GNSI; however it only explains 8.432% of the TVE, and 12.3% of the total cumulative variance explained (CTVE).

The key policy implication is that, within the economy, MHTI cannot price risk adequately and hence are severely constrained in investing in innovativeness and innovation especially given unsophisticated markets that do not demand innovative products and services.

Other policy implications involve: (i) Government and Industry needing to engage in a standing dialogue to align priorities through targeted policy. This is vital if MHTI is to be able to firstly more accurately price risk as a function of Government transparently signalled legislative intentions regarding higher resolution 'Standards Setting', 'Regulation', and 'Government Procurement'; (ii) compliant with WTO obligations, MHTI should be enabled to take advantage of explicit policy support, financing and defraying the costs of research and development through fiscal policy[82]; (iii) the 'central nervous system' of the economy – the ICT network capacity and related-skills capability – needs to be seriously upgraded in order to enable enhanced logistics, distribution and transport connectivity, and hence accelerate the flows of goods, services and DISK within the economy. This would begin to generate noticeable externalities associated with competition and the ICT intermediated business-to-business operational modalities prevalent in EMEs and industrialised countries; (iv) the state and performance of Ghana's ICT system which is provided by the profile of networked readiness provided in Tables 9.11 above and 9.12 below, as well as Figure 9.21 below. Specifically, with respect to ICT variables, Ghana ranks between 85th and 131st of 142 countries, according to the World Economic Forum (2012).

[80] According to Adepoju (2007) Ghana was a top ten source of migration of professionals to the UK with an outflow of some 21,500 (1990-2001). The outflow estimates for 1995-2002 are 60% of medical officers, 27% of dentists, 43% of pharmacists, 19% of medical laboratory technicians, and 20% nursing/midwifery personnel. The number of Ghanaians living in OECD countries is estimated at 150,665 of which 34% are classified as highly-skilled (2000/2001). See Adepoju, A., 2007. *Migration in Sub-Saharan Africa*. Background paper commissioned by the Nordic Africa Institute for the Swedish Government White Paper on Africa.

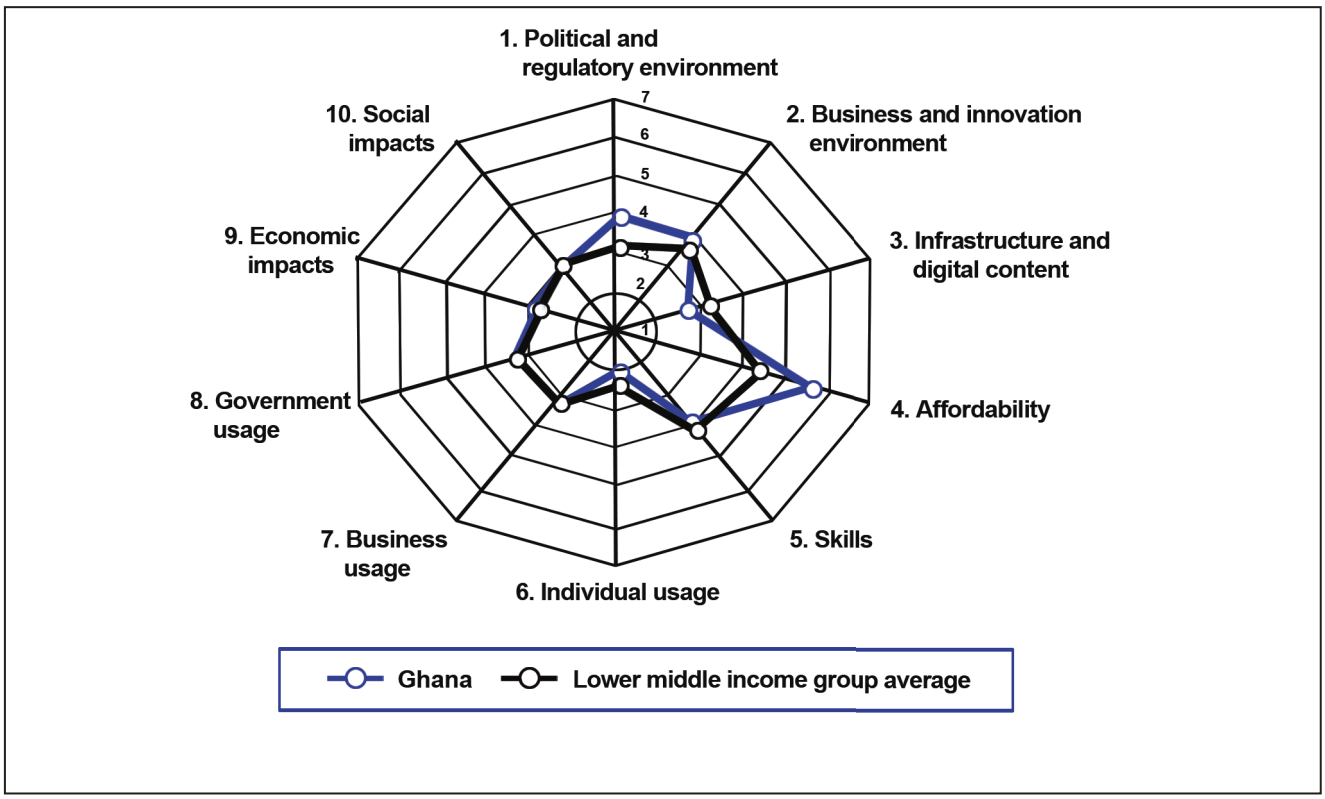
[81] While these two groups may constitute about 30% of the population they represent a disproportionally high percent of those who migrate.

[82] See WTO Non-Actionable Subsidies (R&D, knowledge generation fiscal/monetary support): WTO (World Trade Organization), 1994. Agreement on Subsidies and Countervailing Measures. Identification of Non-Actionable Subsidies, s. IV(8).

***Table 9.12** – Ghana's Networked Readiness (Details)*

| The Networked Readiness Index in Details | | | | | |
|---|---|---|---|---|---|
| Indicator | | Value | Indicator | | Value |
| 1st Pillar: Political and Regulatory Environment | | | 6th Pillar: Individual Usage | | |
| Effectiveness of lawmaking bodies* | 37 | 4.2 | Mobile phone subscriptions, 100/pop. | 106 | 71.5 |
| Laws relating to ICT* | 104 | 3.3 | Individuals using Internet, % | 119 | 9.6 |
| Judicial independence* | 59 | 4.1 | Households with personal computer, % | 107 | 9.1 |
| Efficiency of legal system in settling disputes* | 43 | 4.2 | Households with Internet access, % | 131 | 0.4 |
| Efficiency of legal system in changing regulations* | 62 | 3.8 | Broadband Internet subscription, 100/pop | 115 | 0.2 |
| Intellectual property protection* | 88 | 3.1 | Mobile broadband subscription, 100/pop | 96 | 0.6 |
| Software piracy rate, % software installed | n/a | n/a | Use of virtual social networks* | 112 | 4.5 |
| No. of procedures to enforce a contract | 55 | 36 | 7th Pillar: Business Usage | | |
| No. of days to enforce a contract | 57 | 487 | Firm-level technology absorbtion | 109 | 4.2 |
| 2nd Pillar: Business and Innovation Management | | | Capacity for innovation | 93 | 2.7 |
| Availability of latest technologies* | 94 | 4.6 | PCT patents, applications, million/pop | 108 | 0.0 |
| Venture capital availability* | 123 | 2.0 | Extent of business Internet use* | 103 | 4.5 |
| Total tax rate, % profits | 48 | 33.6 | Extent of staff training* | 81 | 3.8 |
| No. of days to start a business | 52 | 12 | 8th Pillar: Government Usage | | |
| No. of procedures to start a business | 72 | 7 | Government prioritisation of ICT* | 87 | 4.4 |
| Intensity of local competition* | 67 | 4.9 | Importance of ICT for government vision* | 85 | 3.7 |
| Tertiery education gross enrollment rate, % | 115 | 8.8 | Government online service index*, 0-1 (best) | 119 | 0.15 |
| Quality of management schools* | 72 | 4.1 | 9th Pillar: Internet Impacts | | |
| Government procurement of advanced tech.* | 95 | 3.3 | Impact of ICT on news services and products* | 79 | 4.3 |
| 3rd Pillar: Infrastructure and Digital Content | | | ICT PCT patents, applications/million pop | 96 | 0.0 |
| Electricity production, kWh/capita | 115 | 359.3 | Impact of ICT on new organizational models* | 101 | 0.15 |
| Mobile network coverage, %/population | 117 | 77.0 | Knowledge-intensive jobs, % workforce | n/a | n/a |
| Int'l Internet bandwidth, kb/s per user | 122 | 1.5 | 10th pillar: Social impacts | | |
| Secure Internet servers, million/population | 111 | 1.7 | Impacts of ICT on access to basic services* | 103 | 3.9 |
| Accessibility of digital content* | 118 | 3.9 | Internet access in schools* | 110 | 3.2 |
| 4th Pillar: Affordability | | | ICT use & government efficiency* | 110 | 3.6 |
| Mobile celular tariffs, PPP $/minute | 20 | 0.12 | E-participation index, 0-1 (best) | 99 | 0.99 |
| Fixed broadband Internet tariffs, PPP $/month | 84 | 39.82 | Note: Indicators followed by an asterisk* are measured on a 1-to-7 (best) scale. For further details and explanation, please refer to the section "How to read the Country/Economy Profiles" on page 171 of the Global Information Technology Report 2012. | | |
| Internet & telephony competition, 0-2 (best) | 65 | 1.90 | | | |
| 5th Pillar: Skills | | | | | |
| Quality of educational system* | 74 | 3.6 | | | |
| Quality of math and science education* | 98 | 3.4 | | | |
| Secondary education enrollment rate, % | 111 | 58.3 | | | |
| Adult literacy rate, % | 119 | 66.6 | | | |

*Figure 9.21 –Ghana Compared to Lover Middle Income Group Average*




Source: Dutta, S. and Bilbao-Osorio, B., eds. 2012. The Global Information Technology Report 2012: Living in a Hyperconnected World. 10: 92-95044-33-9. Geneva: World Economic Forum.

### 9.5.5.5 Latent Factors to Barriers to Innovation – Knowledge-Based Institutions

*Table 9.13 –Latent Factors to Barriers to Innovation (Knowledge-Based Institutions)*

| Knowledge-Based Institution Respondents (KBI) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Name of Factor | Variables | Factor Loading | Cronbach's Alpha | Total Variance Explained (TVE)% | KMO | Bartlet's Test of Sphericity | | |
| | | | | | | | Chi Squared | Df | Significance |
| 1 | Poor Human Capital | • Lack of technically trained manpower<br>• Quality of technically trained manpower | 0.846<br>0.786 | 0.862 | 32.466 | 0.786 | 874.204 | 136 | 0.000 |
| 2 | Sophisticated Markets | • Lack of demanding customers<br>• Lack of innovative customers<br>• Lack of competition | -0.901<br>-0.846<br>-0.585 | 0.741 | 9.579 | | | | |
| 3 | Organisational Risks | • Excessive perceived economic risk<br>• Organisational rigidities<br>• Restrictive public/ governmental regulations<br>• Hierarchical organisations | 0.764<br>0.744<br>0.743<br>0.576 | 0.751 | 8.579 | | | | |
| 4 | ICT Stocks & Flows | • ICT capacity<br>• Rate of access to ICT | 0.890<br>0.856 | 0.925 | 7.006 | | | | |
| 5 | (THIS FACTOR IS NOT RELIABLE & HENCE NOT NAMED) | • Lack of explicit policy support<br>• Lack of finance | 0.862<br>0.749 | 0.506<br>Cumula-tive Total (CTVE) | 6.652<br>64.281 | | | | |

NB: Residuals are computed between observed and reproduced correlations. There are 60 (44.0%) non-redundant residuals with absolute values greater than 0.05.

- From the perspective of KBI Respondents, Factor 1 <Poor Human Capital> is the highest barrier to innovation in the GNSI, in which the 'Lack of Technically Trained Manpower' and 'Quality of Technically Trained Manpower' are the most crucial variables. The Factor accounts for 71.6% and 61.8% of the variance in the respective variables. Factor 1 accounts for 32.466% of TVE.

- Factor 2 <Sophisticated Markets>, the second highest barrier to innovation accounting for 9.579% TVE, influences the policy variables 'Lack of Demanding Customers', 'Lack of Innovative Customers' and 'Lack of Competition', and accounts for 81.2%, 71.6% and 34.2% of variance in the variables, respectively.

- Notably, Factor 3 <Organisational Risks> is the third highest barrier to innovation. The factor accounts for 8.579% TVE and accounts for 58.4%, 55.4%, 55.2% and 33.2% of the variance in the respective variables ('Excessive Perceived Economic Risk', 'Organisational Rigidities', Restrictive Public/Governmental Regulations' and 'Hierarchical Organisations').

- Factor 4 <ICT Stocks & Flows> is also a significant barrier to innovation; however it only explains 7.006% of the TVE and 10.9% of the CTVE. The factor accounts for 79.2% and 73.3% of the variance in the respective variables 'ICT Capacity' and 'Rate of Access to ICT.

The key policy implication is that, convergent with Factor 1 (ALL Respondents) and Factor 1 (GOV Respondents), without adequate thresholds of human capital, the level of innovativeness and rate of innovation in the economy is likely to be debilitating and inadequate to close the gap with the median middle-income countries.

Secondary implications are: (i) KBI view of Factor 2 <Sophisticated Markets> does not converge with the view of ALL Respondents, GOV Respondents, or MHTI Respondents. This has to be viewed through the lens of KBI inter-linkages with other Actors, which are either very weak for HE, with respect to ARB, FI, ISTC and BEs, or non-existent for RI (see Figures 9.7 and 9.8 above). This isolation of KBIs may inhibit their appreciation and understanding of markets in terms of the dynamic forces of competition (Porter, 1990, 1981); (ii) even if KBIs wish to commercialise DISK, due to their very weak or nonexistent linkages, they find no reception in the market. One of the primary sources of DISK is RI, and RI inter-linkages with FIs, ARBs, ISTC and BEs are nonexistent. This is confirmed with respect to an Actor-centric view of the GNSI, in which KBI have no proactive linkages with ARB, and ARB have no proactive or passive linkages with KBIs. 64.4% of KBIs view the passive link [HE] BE-HE as VI-VW. MHTI has both proactive and passive linkages with KBI, but 58.4% and 53.3% of MHTI Respondents view [HE] BE-HE and [BE] HE-BE as VI-VW respectively (see Figures 9.12 and 9.13 above); (iii) KBIs are far from fully reorienting their role toward corporate entrepreneurship in which, incentivised by governmental fiscal, monetary, regulation and performance requirements, they exploit and commercialise DISK; (iv) The Government's 'arm's length' relationship with KBI, with respect to innovativeness and innovation performance requirements (see figures 9.12 and 9.13 above), tends to preclude adaptive behaviour by KBIs, as well.

An overview of the factor barriers to innovation in the GNSI highlights four major recurrent policy dimensions that constrict innovativeness and innovation, and explain in tandem with the general very weak Actor inter-linkages the overall very low levels of innovativeness of BEs identified earlier.

These policy dimensions are characterised as follows: <<Organisational Capital>> manifests as deficiencies in human capital Skills-ICT Capability/Capacity; <<Market Demand>> manifests as insufficiencies in the level and quality of demand; and, <<Organisational Constraints>> manifest as risks and rigidities that stem adaptive response mechanisms in the behaviour of Actors. Additional to these three policy dimensions that conform the factor barriers, a fourth policy dimension exists, namely <<Fiscal and Monetary>>, which is manifest as financing shortfalls with respect to supporting risk appetite and Actors' efforts in innovativeness.Taken together, these policy dimensions are responsible for the present state of the GNSI, which may be characterised as: (i) asymmetric in its density and distribution of Actor inter-linkages and hence lacking in strategic coherence, organisational performance and externalities; (ii) largely unresponsive to the supply- and demand-side signals of the economy[83]; and, (iii) systematically rigid and inflexible to changing conditions.

The policy recommendations to address the dimensions and factor barriers to innovation and innovativeness should be viewed together through the lens of a short-, medium- and long-term frame of reference. A matrix of such is presented further on in the Report to guide policy-making.

The policy recommendations to address the deficiencies in <<Organisational Capital>>[84]within the GNSI include: (i) recalibrating curricula reform to the needs of MHTI; (ii) reorienting the quantity and quality of secondary and tertiary education, and vocational training, as well as enterprise-based training toward STEMIT and management to enable increases in the employment of STEMIT professionals[85]; (iii) increasing

[83] This is a reciprocal challenge. On the one hand the demand-side is unsophisticated in its needs and wants in products and services; and on the other hand (due to poor quality of demand) the supply-side offers little or no innovation or innovative products and services at a level and rate to catalyse innovativeness. Also, from a diffusion of innovation perspective, the size of the market for innovative products and services is relatively small in Ghana.

[84] Defined as "...the knowledge [capabilities and capacities] used to combine human skills and physical capital into systems for producing [efficiently] and delivering [effectively] want-satisfying products." Cited by Lev and Radhakrishnan (2003, p.4). These are structurally manifest in operational, investment and innovation abilities. See Evenson, R.E. and Westphal, L.E., 1995. Technological change and technological strategy. In: J. Behrman and T. N. Srinivasan, eds. 1995. *Handbook of Development Economics, Volume 3A*. Amsterdam: Elsevier, pp. 2209-2299.

[85] In order for such reorientation not to result in contributions to the brain drain, the structure of training, qualifications and remuneration will have to be changed so that friction of movement is high. The current orientation of research professionals in Ghana is 17.1% natural sciences, 19.4% engineering and technology, 5.8% medicine and health , 36.0% agricultural sciences, 19.3% social sciences, and 2.2% humanities (see AU-NEPAD, 2010).

the fiscal and management autonomy of KBIs conditioned on joint training programmes with MHTI, such that STEMIT courses are increasingly grounded in Business Enterprises; (iv) given the spatial distribution of GNSI Actors, upgrading the information infrastructure to enable ICT diffusion in 'super corridors' and 'super region'[86 87]; (v) reducing ICT network costs (cutting taxes on ICT products and services, subsidizing for broadband roll-out, and Government lead in ICT infrastructure provision); (vi) upgrading the ICT information infrastructure specifically for KBIs, i.e. the creation of a high-speed national research and education network to link all universities, Government agencies and RI[88]; and, (vii) to mitigate the brain drain[89], supporting a Government direct sponsorship of rolling National Development Conferences to network the diaspora and local entrepreneurship[90].

The policy recommendations to address the insufficiencies in <<Market Demand>> with respect to the GNSI include: (i) the use of standards-based regulation and performance requirements to coerce firms toward technological adaptation[91] through environmental standards, economic performance measures, voluntary agreements and directives on innovation in specific sectors; (ii) use of 'Standards Setting' and 'Regulation' in the managerial accounting domain for accelerated depreciation of capital to increase the rates of substitution of capital for labour; (iii) the reconfiguration of public procurement terms and conditions toward innovativeness[92 93]; (iv) from a product/technology 'push' perspective, strengthen incentives for commercialisation of publicly funded R&D at KBIs[94]; and, (v) initiation of a patent management corporation to co-ordinate the the commercialisation of IPRs.

The policy recommendations to address <<Organisational Constraints>> of the GNSI, i.e. policies to reduce obstacles counter to innovativeness and entrepreneurship[95], include: (i) reconfiguring business regulation to reduce the number of processes, the length of time, and the cost to start a business through analysis of bottlenecks and costs; (ii) eliminating bottlenecks in granting permits and securing access to power; (iii) speeding up the procedures to register property (and hence ability to collateralise assets); (iv) use Government-Backed Venture Capital to ease access to credit for entrepreneurship; (v) ensuring the protection of investors through the courts; (vi) recalibrating the tax regime to favour entrepreneurship and innovation; (vii) reducing barriers to cross-border trade (documentation, etc.); (viii) reducing the cost of contract enforcement; (ix) reducing the time to resolve insolvency in order to accelerate business entry and exit dynamics[96]; (x) initiating a programmatic co-ordination of support to innovation, having at its core performance of regular, independent evaluations with international comparators; and, (xi) initiating a programme to enhance the technology absorptive capacity and capability of SMEs in MHTI[97].

The policy recommendations to address <<Fiscal and Monetary Deficiencies>> in the GNSI include: (i) auditing MHTI to identify early adopters and early majority firms as promising local companies in the diffusion of innovation paradigm; (ii) aligning funding, fiscal and monetary support to promising local company performance; and, (iii) recalibrating the corporate tax regime to reduce innovation costs.

[86] The super region of Ashanti, Eastern and Greater Accra; and the super corridors linking Greater Accra, Eastern and Ashanti region with the Northern region along the axes Accra-Kumasi-Sunyani-Tamale-Bolgatanga, Accra-Winneba-Cape Coast-Sekondi-Takoradi.

[87] This is in concert with the Government of Ghana initiative to "expand infrastructure to promote access to ICT… [by] …the construction of ICT Innovation Centres to facilitate the application of ICT learning and research in the Upper East, Upper West, Ashanti, Volta, and Northern Regions" (Government of Ghana Budget., 2012., pg 578).

[88] Using fibre optics to provide capacity of 100 Gbps.

[89] According to The Economist (2 Jan. 2003, p.26), as many as a third of Ghana's highly educated human capital live overseas.

[90] Such events should address strategically concerns such as: creating an enabling environment, removing bureaucratic impediments, reducing hierarchical structures, and organisational rigidities that prevent knowledge transfers between internationals and locals. This is absolutely crucial as a policy issue as "the global skills shortage shows no signs of improving". See Financial Times (29 May 2012, p.17, manpower survey of 38,000 firms in 41 countries).

[91] See Foxon et al., 2004. Innovation Systems and Policy-Making Processes for the Transition to Sustainability. In: K. Jacob, M. Binder and A. Wieczorek, eds. 2004. *Governance for Industrial Transformation. Proceedings of the 2003 Berlin Conference on the Human Dimension of Global Environmental Change.* Berlin: Environmental Policy Research Centre (EPRC), pp.96-112.

[92] e-filling, triangulation, R&D component, etc.

[93] This is in concert with Government directive to review "the system design for e-procurement policy recognising the need for quick results, level of technological capacity, organisation and expertise within the public and private sectors: (Government of Ghana Budget., 2012., pg. 586).

[94] In relation to the Patent Act 2003 (Act 657), through legislation that emulates acts such as the US Bayh-Dole Act (1980) which clarifies intellectual property rights arising in the public sector with public funds in order to accelerate commercialisation of government funded R&D by designing incentives for KBIs (HE, RI).

[95] This is in concert with Government directive to develop "the Centre for Entrepreneurship, Employment and Innovation Initiative (CEEII) as a one stop shop to facilitate business startups, finance, business ideas, evaluation, monitoring and business development"(Government of Ghana Budget., 2012., pg. 280)

[96] These policy recommendations reflect the World Bank Doing Business Series. Ghana's ranking out of 183 economies has worsened in seven out of ten policy areas since 2011.

[97] Policy implementation approaches should include: KBI outreach programmes with respect to CAD/CAM, product design, technology resource centres, technology offices for SMEs in MHTI, capital subsidies for SMEs MHTI upgrading.

**Survey Analysis:** Deficiencies in organisational capital, market demand, coupled with organisational constraints and fiscal and monetary shortfalls.

**Policy Implication:** Barriers to innovation to be tackled economy-wide as well as in terms of Actor-specific interventions.

**Policy Recommendation:** emphasise STEMIT in education, use standards to increase sophistication of demand, reduce bottlenecks in doing business and recalibrate tax regime to support innovation.

### 9.5.6 Success of Policy Instruments and Barriers to Innovation

The identification of the policy dimensions, factors and variables acting as high barriers to innovativeness and innovation in the GNSI suggests policy implications. The disposition of the factors suggests the sequencing of policy prescriptions and recommendations. However, such policy prescriptions and recommendations, in terms of Actor business plans and management actions need to be set in the context of the extant policies of Government supporting innovativeness and innovation in the economy. To this end, an analysis of success of policy instruments and barriers to innovation was performed and, presented in Table 9.14 below.

Table 9.14 indicates the cross-tabulation relationship between policy instruments and barriers to innovation as discussed in the section below. From all the statistically significant (≥95% confidence level) cross-tabulation results, only those results representing a majority assessment (≥50%) by Respondents are reported. In all cases, ALL Respondents represented indicate that the available policy instruments are unsuccessful with respect to barriers to innovation, each of which is seen as a very high constraint.

Firstly, some assessments of policy instruments success and barriers to innovation by ALL Respondents are corroborated (by the other Actors in the GNSI). These are discussed below.

- Government-Backed Venture Capital – is inadequately calibrated to remove barriers to innovation: 'Lack of Explicit Policy Support' (KBIs); 'Lack of Technically Trained Manpower' (GOV and MHTI); 'Quality of Technically Trained Manpower' (GOV and MHTI); and, 'Excessive Perceived Economic Risk' (MHTI).

- Standards Setting – is inadequately calibrated to remove the barrier to innovation: 'Lack of Explicit Policy Support' (KBIs).

- Regulation – is inadequately calibrated to remove the barrier to innovation: 'Lack of Explicit Policy Support' (KBI).

- Labour Mobility (Laws, Incentives) – is inadequately calibrated to remove the barrier to innovation: 'Lack of Explicit Policy Support' (GOV).

- ICT Access – is inadequately calibrated to remove barriers to innovation: 'Lack of Finance' (MHTI); and, 'Innovation Costs Too High' (GOV and MHTI).

Secondly, some assessments of policy instruments success and barriers to innovation by ALL Respondents are not corroborated by the other Actors in the GNSI. Multiple policy instruments map to a singular barrier to innovation variable (not including the corroborations), which are discussed below:

- With respect to the barrier to innovation 'Lack of Finance', four policy instruments – Government-Backed Venture Capital, Donor Funds, Government Procurement and Regulation – are inadequately calibrated to remove the barrier.

- With respect to the barrier to innovation 'Lack of Technically Trained Manpower', two policy instruments – Subsidised Loans and Regulation – are inadequately calibrated to remove the barrier.

- With respect to the barrier to innovation 'Organisational Rigidities', two policy instruments – Government-Backed Venture Capital and Labour Mobility (Laws, Incentives) – are inadequately calibrated to remove the barrier.

Thirdly, some assessments of policy instruments' success and barriers to innovation by ALL Respondents are not corroborated by the other Actors. Singular policy instruments map to a singular barrier to innovation variable, which are discussed below:

- Research Grants – are inadequately calibrated to remove the barrier to innovation: 'Lack of Explicit Policy Support'

- Tax Breaks – are inadequately calibrated to remove the barrier to innovation: 'Brain Drain'

- Donor Funds – are inadequately calibrated to remove the barrier to innovation: 'Lack of Finance'

- Government Procurement – is inadequately calibrated to remove the barrier to innovation: 'Lack of Finance'

Fourthly, some assessments of policy instruments success and barriers to innovation by Actor Respondents are not corroborated by the other Actors. Singular policy instruments map to singular barriers to innovation variable, which are discussed below from an Actor perspective:

- From the GOV perspective:
  - Labour Mobility (Laws, Incentives) – is inadequately calibrated to remove the barrier to innovation: 'Lack of Explicit Policy Support'

***Table 9.14** – Policy Instrument Success and Barriers to Innovation*

| | | All Actors % | | GOV % | | MHTI % | | KBIs % | | Arbitrageur % | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Policy Instruments | Barriers to Innovation | VHS-VLC | US-VHC | VHS-VLC | US-VHC | VHS-VLC | US-VHC | VHS-VLC | US-VHC | VHS-VLC | US-VHC |
| Research Grants | Lack of explicit policy support | 1.8 | 61.5 | | | | | | | | |
| Tax Breaks | Hierarchical organisations | | | | | | | | | 33.3 | 66.7 |
| | Brain drain | 3.0 | 53.0 | | | | | | | | |
| Subsidised Loans | Lack of explicit policy support | | | | | | | 1.6 | 69.0 | | |
| | Lack of technically trained manpower | 5.1 | 56.1 | | | | | | | | |
| | Quality of technically trained manpower | 3.8 | 54.2 | | | | | | | | |
| | Innovation costs (too high) | | | | | 0.0 | 53.3 | | | | |
| | Excessive perceived economic risk | | | | | | | | | 0.0 | 50.0 |
| Government-Backed Venture Capital | Lack of explicit policy support | 3.4 | 64.9 | | | | | 3.9 | 62.8 | | |
| | Lack of finance | 1.3 | 66.6 | | | | | | | | |
| | Lack of technically trained manpower | 6.5 | 54.2 | 7.7 | 59.0 | 5.0 | 53.4 | | | | |
| | Quality of technically trained manpower | 6.4 | 53.9 | 7.7 | 56.3 | 5.0 | 52.0 | | | | |
| | Organisational rigidities | 4.2 | 50.3 | | | | | | | | |
| | Innovation costs (too high) | | | | | 0.0 | 60.0 | | | | |
| | Excessive perceived economic risk | 3.8 | 51.7 | | | 6.7 | 56.7 | | | | |
| | Rate of access to ICT | | | | | | | 7.0 | 52.7 | | |
| | ICT capacity | | | | | | | 7.0 | 53.6 | | |
| Donor Funds | Lack of finance | 2.1 | 57.3 | | | | | | | | |
| | Lack of technically trained manpower | | | | | | | | | 0.0 | 50.0 |
| | Brain drain | | | | | 8.4 | 50.0 | | | | |
| | Innovation costs (too high) | | | | | 0.0 | 51.6 | | | | |
| Government Procurement | Lack of finance | 2.2 | 66.6 | | | | | | | | |
| Standard Setting | Lack of explicit policy support | 2.2 | 60.7 | | | | | 0.8 | 60.4 | | |
| Regulation | Lack of explicit policy support | 3.8 | 61.4 | | | | | 3.1 | 58.9 | | |
| | Lack of finance | 2.2 | 63.3 | | | | | | | | |
| | Lack of technically trained manpower | 8.2 | 51.3 | | | | | | | | |
| | Lack of information (knowledge gap) | 5.1 | 50.8 | | | | | | | | |
| | Excessive perceived economic risk | | | | | | | | | 16.7 | 50.0 |
| Labour Mobility (Laws, Incentives) | Lack of explicit policy support | 3.0 | 65.8 | 5.2 | 71.8 | | | | | | |
| | Organisational rigidities | 4.3 | 50.8 | | | | | | | | |
| | Excessive perceived economic risk | 3.0 | 50.4 | | | | | | | | |
| ICT Access | Lack of explicit policy support | | | 7.7 | 66.7 | | | | | | |
| | Lack of finance | 1.7 | 59.7 | | | 6.7 | 56.7 | | | | |
| | Innovation costs (too high) | 0.8 | 54.3 | 2.6 | 51.4 | 0.0 | 51.7 | | | | |

VHS-VLC = Very High Successful (Policy Instrument) – Very Low Constraint (Barrier to Innovation)

US-VHC = Unsuccessful (Policy Instrument) – Very High Constraint (Barrier to Innovation)

- From the MHTI perspective:
  - Subsidised Loans – are inadequately calibrated to remove the barrier to innovation: 'Innovation Costs (Too High)'

- From the KBI perspective:
  - Subsidised Loans – are inadequately calibrated to remove the barrier to innovation: 'Lack of Explicit Policy Support'
  - Standard Setting – are inadequately calibrated to remove the barriers to innovation: 'Lack of Explicit Policy Support'
  - Regulation – is inadequately calibrated to remove the following barrier to innovation: 'Lack of Explicit Policy Support'

- From the ARB perspective:
  - Tax Breaks – are inadequately calibrated to remove the barrier to innovation: 'Hierarchical Organisations'
  - Subsidised Loans – are inadequately calibrated to remove the barrier to innovation: 'Excessive Perceived Economic Risk'
  - Donor Funds – are inadequately calibrated to remove the barrier to innovation: 'Lack of Technically Trained Manpower'
  - Regulation – is inadequately calibrated to remove the barrier to innovation: 'Excessive Perceived Economic Risk'

Bearing in mind the policy dimensions of the factor barriers identified previously, the policy analysis above shows patterns with respect to policy instruments success (or lack of) and barriers to innovation. These reflect the factor barriers to innovation. In general, policy instruments are neither well-configured nor adequately calibrated to address barriers to innovation in the GNSI.

Firstly, from an Actor perspective, the rank (descending) order of significant assessment of policy instruments and barriers is: MHTI (nine assessments); KBI (six); GOV (five); and, ARB (four). Secondly, corroboration of US-VHC is densest across policy instruments – Government-Backed Venture Capital – and – ICT Access (GOV and MHTI) with respect to barriers 'Lack of Technically Trained Manpower'; 'Quality of Technically Trained Manpower' and 'Innovation Costs (too high)'[98]. Thirdly, from the Actor's perspective, the most recurrent barriers inadequately addressed by policy instruments are: (i) 'Lack of Explicit Policy Support' (six, KBI and GOV) is inadequately addressed by policy instruments – Subsidised Loans, Government-Backed Venture Capital, Standards Setting, Regulation, Labour Mobility (Laws, Incentives) and ICT Access; (ii) 'Innovation Costs (too high)' (five, GOV and MHTI) is inadequately addressed by policy instruments – Subsidised Loans, Government-Backed Venture Capital, Donor Funds, and ICT Access; (iii) 'Excessive Perceived Economic Risk' (three, MHTI and ARB) is inadequately addressed by policy instruments – Subsidised Loans, Government-Backed Venture Capital, Regulation.

[98] This is expected as deficiencies in human capital raise the costs of innovativeness and innovation due to penalties associated with low productivity.

It is notable that Respondents do not associate significantly success (or failure) of policy instruments with the market-oriented barriers to innovation: 'Lack of Demanding Customers', 'Lack of Innovative Customers', and 'Lack of Competition'. It is instructive, however, to examine, at a finer grain, the barrier to innovation that is the most influenced by the factors across ALL and each set of Actor Respondents. This is 'Lack of Demanding Customers' and respectively (ALL) Factor 2 <Unsophisticated Markets> is responsible for 79.6% of the variation in the variable. Likewise, (GOV) Factor 2 <Unsophisticated Markets> is responsible for 87.4%; (MHTI) Factor 3 <Unsophisticated Markets> accounts for 82.6%; and, (KBI) Factor 2 <Sophisticated Markets>[99] accounts for 81.2%[100] (see Tables 9.7, 9.8, 9.10 and 9.13 above).

On ranking the factors (by GNSI Actor) by the TVE in descending order (a measure of the explanatory power of the Factor, which enables prioritisations, decision trade-offs and sequencing in policy craft), see Table 9.15 below – Ranking of Factor (Total Variance Explained).

The main policy implications of the above policy analysis are: (i) the two primary policy instruments – Government-Backed Venture Capital and ICT Access – (once recalibrated) are strategically crucial to addressing and overcoming the systemic deficits in the <<Organisational Capital>> of the GNSI[101]; (ii) the policy instruments – Subsidised Loans, Regulation, Standards Setting, and Labour Mobility (Laws, Incentives) – (once recalibrated) are operationally crucial to addressing and overcoming the system-wide <<Organisational Constraints>> within the GNSI, in support of addressing the deficits in the Organisational Capital of the GNSI. (iii) three major specific barriers to Innovation variables, namely, 'Lack of Explicit Policy Support', 'Innovation Costs (too high)' and 'Excessive Perceived Economic Risk', need to be the target of focused attention of policy prescription and instruments; (iv) judicious policy prioritisation and sequencing suggests the following policy timeframe and target with respect to policy instrument recalibration to overcome barriers to innovation (see Table 9.16 below).

The table needs to be read as a 'rolling' policy frame of reference which is programmatic, rather than static, and which is consistent with legislative processes of government.

The precondition for policy recommendations to address the poorly configured and inadequately calibrated policy instruments and interventions is anchoring innovation policy

[99] The variables load negatively on this factor.

[100] This is consistent with the literature and empirical evidence that markets (demand) are prime driver of innovation through the logic of industrial competition and the dynamics of the forces of competition (Bartels et al., 2012; Porter, 1990).

[101] In the sense that Venture capital is used innovatively for skills upgrading and nurturing entrepreneurial talent. See Saxenian, A., 2005. From Brain Drain to Brain Circulation: Transnational Communities and Regional Upgrading in India and China. *Studies in Comparative International Development,* 40(2), pp.35-61; Andersson T. and Napier G., 2007. *The Role of Venture Capital, Global Trends and Issues From a Nordic Perspective*. Malmo: IKED.

***Table 9.15** – Ranking of Factor (Total Variance Explained)*

| Rank | Actor | Factor | % TVE |
|---|---|---|---|
| 1st | MHTI | F1 <Organisational Risks> | 40.52% |
| 2nd | KBIs | F1 <Poor Human Capital> | 32.466% |
| 3rd | GOV | F1 <Constrained Human Capital Resources> | 26.75% |
| 4th | GOV | F2 <Unsophisticated Markets> | 14.152% |
| 5th | MHTI | F2 <Deficient Fiscal Policy> | 10.759% |
| 6th | GOV | F2 <Organisational Risk> | 10.669% |
| 7th | KBIs | F2 <Sophisticated Markets> | 9.579% |
| 8th | GOV | F4 <Constrained ICT Stocks & Flows> | 9.028% |
| 9th | MHTI | F3 <Unsophisticated Markets> | 8.988% |
| 10th | KBIs | F3 <Organisational Risks> | 8.579% |
| 11th | MHTI | F4 <ICT Skills Incapacity/Incapability> | 8.432% |
| 12th | KBIs | F4 <ICT Stocks & Flows> | 7.006% |

NOTE: Table 9.15 should be read with the TVE rank of factors by ALL Respondents.

***Table 9.16** – Timeframe for Policy Instruments*

| Policy Time Frame | Target | Policy Instruments | Barriers to Innovation |
|---|---|---|---|
| 1. Short-term (1-3 years) | • GNSI system wide; KBIs; GOV | • Government-Backed Venture Capital,<br>ICT Access | 'Lack of technically trained manpower', 'Quality of technically trained manpower'; |
| 2. Medium-term (3-5 years) | • GNSI system wide; KBIs<br>• GNSI system wide;<br>• GNSI system wide MHTI ARBs | • Subsidised Loans, Standard Setting, Regulation, Labour Mobility (lack of information);<br>• Donor Funds;<br>• Subsidised Loans, Regulations | 'Lack of explicit policy support', 'Innovation costs (too high)', 'Excessive perceived economic risks' |
| 3. Long-term (5+ years) | • Economy wide | • Standard Setting, Regulation, (Tax Breaks) | 'Lack of demanding customers', 'Lack of innovative customers' |

more firmly within a strategically coherent industrial policy[102]. Five areas of policy recommendations that are apposite are:

- towards an innovation economy;
- public procurement and innovation;
- business incubation;
- STEMIT as the prime drivers of innovation; and,
- absorbing international innovation.

With respect to an innovation economy, the policy recommendations include: (i) following the evidence of policy measurement, develop a customised innovation policy with quantitative targets; (ii) use peer (middle-income country) innovation metrics[103] to track and measure policy progress and effectiveness driven by the GNSI longitudinal surveys using UNIDO methodology; (iii) embedding a culture of innovation across the management of the economy; (iv) orienting policy to address the key challenges of innovation facing the national economy[104]; and, (v) creating a departmental unit in the Ministry of Education (Department of KBI Skills and Innovation – (KBISI)) that, along with the SETIRC and the GNSIPU, ensures innovativeness across GNSI Actor behaviour.

Regarding public procurement and innovation, policy recommendations include: (i) deploying the weight of Government spending power, public procurement and public services demand, to reconfigure the environment for innovation and innovativeness; (ii) requiring all Government departments to develop an innovation procurement plan in respect of stimulating innovativeness through public spending; (iii) GNSIPU and Department of KBISI to facilitate mobility of private sector personnel into the public sector with respect to innovative procurement practices; (iv) using Government procurement (central, regional, local) to create 'lead markets' for innovative products and services; (v) Government to have a posture of an 'early adopter' in the diffusion of innovation paradigm[105]; (vi) consolidate public procurement Authority, Agency, Board into a new Government Procurement Service with a mandate to procure

[102] Component two of Ghana industrial is technology and innovation, however policies in support of industrial innovativeness and innovation need to be better reinforced by complementary policies (fiscal, monetary, energy pricing, standards and regulations).

[103] There are several metrics and methodologies, as well as reports available including from the UN, World Economic Forum, World Competitiveness Report, UNIDO Competitive Industrial Performance Index that can guide policy making. Ghana is marked 76th out of 130 in the 2010-2011 Innovation Capacity Index by the European Business School.

[104] These are: understanding the dynamics of innovation; measuring systemic innovativeness and innovation using the UNIDO methodology; ensuring STEMIT curricula emphasise learning skills; Government to lead by example; and make the most of KBIs placing HE and RIs at the core of innovation policy.

on the basis of innovative solutions; and, (vii) opening up procurement windows for SMEs in MHTI.

With respect to business incubation, a forward looking policy posture needs to recognise that, in the 21st century as international flows of DISK increasingly commoditise knowledge (but not know-how and know-why), there are increasing returns to user-led innovation. Therefore, policy recommendations include: (i) Government as a user of products and services, along with KBIs, to focus on SMEs in MHTI; (ii) KBIs to be required to create business incubators into which is fed the results of STEMIT research at masters, doctoral and post-doctoral research[106]; (iii) differentiate Government support to entrepreneurship much more finely in terms of fiscal/final, managerial and technological levels[107]; and, (iv) leverage Government-Backed Venture Capital with private sector and Arbitrageur funding of incubators.

In keeping with innovation policy as part of a strategic industrial policy, regarding STEMIT as the prime drivers of innovation, STEMIT policy needs to become a core component of economic policy. Policy recommendations include: (i) achieving the government target of 1% of GDP to support STEMIT, then doubling to 2% of GDP within three years; (ii) leveraging private R&D expenditure through fiscal recalibration, matching funds and direct support; (iii) requiring all public expenditure on STEMIT programmes to generate patent, licensing and royalty fees; (iv) initiating a specific KBI Innovation Fund to support STEMIT spin-offs from KBI research; (v) requiring KBIs to perform (in an integrated manner) as a GNSI Actor the roles of: undertaking STEMIT research, pedagogy, knowledge transfer (to/from industry), act as national and regional conduits into the global knowledge economy, and lead in the design and delivery of regional economic development strategies, against performance-based targets[108]; (vi) reorienting education toward life-long learning, STEMIT and for innovation; and, (vii) adopt a geo-spatial information systems (GSIS) approach to policy-making.

With respect to absorbing international innovation, because of the global dynamics of innovation, the GNSI requires an absorptive capacity that enables access to, and diffusion of, innovations from elsewhere. Policy recommendations therefore include: (i) focusing on connecting the urban centres in the super region of Ashanti-Eastern-Greater Accra[109]; (ii) requiring KBIs to develop international partnerships; (iii) measuring KBIs on their absorptive capacity [110] (iv) requiring GNSI Actors to collaborate as a function of Government support; and, (v) requiring Government to fund KBI R&D on the basis of inter-disciplinary collaboration and triangulation [111].

**Survey Analysis:** Unsuccessful policy instruments and very high constraints on innovativeness and innovation.

**Policy Implication:** Poorly configured and inadequately calibrated policy instruments and interventions.

**Policy Recommendation:** Reconfiguration and recalibration of policy instruments and interventions towards a performance based support by government.

The following section analyses the availability of policy instruments and their success.

### 9.5.7 Availability of Policy Instruments & Success

Table 9.17 below presents the available policy instruments and their success (or otherwise) in promoting innovativeness and innovation in the economy.

Across ALL Respondents (together and separately) the overwhelming assessment is that available policy instruments are not successful, with respect to promoting innovativeness and innovation. This reflects earlier findings regarding policy instruments and barriers to innovation. As far as ALL Actors are concerned, a sizeable minority ranging from 26.1% to 38.9% assess the policy instruments as very highly successful, however, the vast majority ranging from 61.1% to 73.8% assess the instruments as not successful.

Regarding GOV Actors, again a sizeable minority 20.5% to 41.1% assesses the policy instruments as very highly successful; however, the vast majority 59.0% to 79.6% assesses the instruments as not successful. With MHTI Actors, a respectable minority 23.4% to 43.2% assesses the policy instruments as very highly successful; however, the vast majority 56.8% to 76.7% assesses the instruments as not successful. Regarding KBI Actors, a respectable minority 23.3% to 39.6% assesses the policy instruments as very highly successful; however, the vast majority ranging from 60.6% to 76.9% assesses the instruments as not successful. The results from GOV, MHTI and KBIs corroborate that from ALL Respondents.

This confirms that extant policy instruments are not overcoming barriers to innovation, either in terms of the factor barriers to innovation or the variables of innovation.

[105] With respect to procurement from Ministries of Health, Education, Defence, Trade and Industry, etc. for example, it is arguable that "Ghana's new approach to public sector reform: focusing on delivery", World Bank, November 2010, places insufficient emphasis on the role of public procurement in driving innovation.

[106] Such incubators to be linked to MHTI along the policy lines recommended earlier. It is estimated that for the U.S. the number of incubators at approximately 1,200 support about 27,000 businesses and generates about US$ 17 billion annually.

[107] Low level fiscal/financial – industrial estates; medium level fiscal/financial, management and technological – business parks and enterprise centres networked with KBIs and MHTI; high level fiscal/financial, management and technological – business and innovation centres science parks, and technological centres networked (on campus) with KBIs, MHTI and ARB.

[108] Such as: research evaluation exercises; teaching assessment exercises; patent, licensing, royalty fees; quality of international and regional linkages; and regional development assessment exercises.

[109] Dunning J., 2000. *Regions, Globalization, and the Knowledge-Based Economy*. Oxford: Oxford University Press.

[110] Based on metrics of: access capacity (capacity to spread 'DISK' in the locality and region), DISK creation capacity (capacity to create knowledge), and DISK exploitation capacity (capacity to commercialise IPRs).

[111] This is in concert with Government directive to "establish a Science and Technology and Innovation Fund (STIFund) to address the perennial problem of inadequate funding for research and development in the long run. A seed capital of Two Million Ghana Cedis (GH¢2,000,000.00) will be provided. The private sector is also being urged to contribute generously to the fund" (Government of Ghana Budget., 2012 pg.104).

***Table 9.17** – Success of Policy Instruments*

| | All Actors % | | Governments % | | MHTI % | | KBIs % | | Arbitrageur % | |
|---|---|---|---|---|---|---|---|---|---|---|
| Policy Instrument | VHS | NS | VHS | NS | VHS | NS | VHS | NS | VHS | NS |
| Research Grants | 34.2 | 66.0 | | | 36.7 | 63.3 | 35.0 | 65.3 | | |
| Tax Breaks | 30.4 | 69.7 | 20.5 | 79.6 | 43.2 | 56.8 | 27.2 | 72.8 | | |
| Subsidised Loans | 26.1 | 73.8 | 23.1 | 77.0 | 33.2 | 66.6 | 23.3 | 76.9 | | |
| Government-Backed Venture Capital | 28.6 | 71.6 | | | 23.4 | 76.7 | 31.8 | 68.5 | | |
| Donor Funds | 38.9 | 61.1 | 41.1 | 59.0 | 36.6 | 63.4 | 39.6 | 60.6 | | |
| Government Procurement | 29.5 | 70.5 | 30.8 | 69.3 | 31.7 | 68.4 | 28.8 | 71.4 | | |
| Standard Setting | 32.5 | 67.3 | 25.6 | 74.4 | 36.7 | 63.3 | 31.1 | 69.0 | | |
| Regulation | 33.2 | 66.6 | 28.2 | 71.8 | 31.7 | 68.2 | 35.0 | 65.2 | | |
| Labour Mobility (Laws, Incentives) | 27.4 | 72.6 | 23.2 | 76.9 | | | 25.7 | 74.6 | | |
| ICT Access | 36.4 | 63.8 | 30.7 | 69.3 | | | 38.0 | 62.1 | | |

In terms of the ranking of highest majority indicating not successful policy instruments from ALL Respondents and each Actor group one sees: (ALL) Subsidised Loans; (GOV 1st) Tax Breaks; (KBI 2nd) Subsidised Loans; and (MHTI 3rd) Government-Backed Venture Capital (see Table 9.17 above).

The policy implications are consistent with those of the previous section on success (or otherwise) of policy instruments and barriers to innovation but with the following nuances: (i) fiscal (and monetary) policy needs recalibrating, consistent with WTO provisions of non-actionable subsidies[112] for accelerating innovativeness and innovation; (ii) the policy instruments that require most urgent recalibration to address and overcome barriers to innovation are: Fiscal (Tax Breaks) arrangements (to enable economy-wide innovativeness and innovation by, for example, altering capital depreciation regulations), Subsidised Loans (to enable KBI to engage in patenting, incubating new ideas, spin-offs from IPRs, generating medium-and high-tech SMEs within university campuses, engaging with MHTI for R&D and product development, earning license and royalty fees, and full-blown commercialisation of research outcomes), and Government-Backed Venture Capital (to engender innovativeness and innovation in the private sector)[113].

The policy recommendations to address unsatisfactory policy instruments include: (i) R&D tax credits, as an incentive for business R&D rates of relief to be adjusted upwards for SMEs in MHTI[114]; and reductions in the wage taxes of R&D personnel in KBIs and MHTI; (ii) initiating a STEMIT research tax incentive programme; (iii) initiating a STEMIT business scholarship programme for post-doctoral researchers to commercialise their research[115]; (iv) recalibrating tax treatment of share options for spin-offs and start-ups to attract experienced managers; and, (v) using Government-Backed Venture Capital to guarantee loans[116].

**Survey Analysis:** Extant policy instruments and their operations are unsuccessful in overcoming barriers to innovation.

**Policy Implication:** Need to recalibrate fiscal and monetary policies to make Tax Breaks, Government-Backed Venture Capital, and Subsidised Loans effective.

**Policy Recommendation:** Lower taxes for R&D personnel and activities.

### 9.5.8 Latent Factors to Policy Success

The policy analysis of success (or failure) of policy instruments in relation to barriers to innovation indicates the shortfalls and where attention should be focused in the GNSI in order to remove asymmetries, rebalance the system toward improved strategic coherence and effective operational performance.

A prioritisation of the policy instruments that require recalibration to the needs of specific Actors, and the GNSI as a whole, has been presented. The factors that influence the policy instruments are identified in order to present the recalibration requirements. These are presented in Tables 9.18, 9.19, 9.20 and 9.21 below.

The tables present the factors that influence significantly policy instruments with respect to dynamism of the GNSI. From ALL Respondents, two factors emerge, namely, Factor 1 <Fiscal and Monetary Support> and Factor 2 <Standards

[112] See WTO 1994. *Agreement on Subsidies and Countervailing Measures*. Identification of Non-Actionable Subsidies, part IV, art. 8.

[113] A remarkable example of this type of policy intervention is the Israeli venture capital industry. Initiated in the 1960s with US$2.5 million government funding, disbursements totaled US$300 million by 1997 and the total value of the funds were US$ 12.2 billion by 2008. See Avnimelech, G., 2009. VC Policy: Yozma Program 15-years Perspective. In: DRUID (Danish Research Unit on Industrial Dynamics), *Summer Conference on Innovation, Strategy and Knowledge.* Copenhagen, Denmark 17-19 June 2009; Avnimelech, G. and Teubal, M., 2003. Israel's Venture Capital Industry: Emergence, Operation and Impact. In: D. Cetindamar, ed. 2003. *The Growth of Venture Capital: a Cross-Cultural Comparison*. London: Praeger.

[114] Rates of relief at 175% for SMEs are not uncommon in countries with a high priority on innovation (see *Innovation nation*, March 2008, Cm7345, UK Government).

[115] See for example the Vanier Canada Graduate Scholarship Programme (www.vanier.gc.ca).

[116] As sunk costs of start-ups and R&D are higher than for ordinary investment in capital machinery.

***Table 9.18** – Latent Factors to Policy Success (ALL)*

| All Respondents (ALL) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Name of Factor | Variables | Factor Loading | Cronbach's Alpha | Total Variance Explained (TVE)% | KMO | Bartlet's Test of Sphericity | | |
| | | | | | | | Chi Squared | Df | |
| 1 | Fiscal & Monetary Support | • Tax breaks<br>• Research grants<br>• subsidised loans<br>• Government-backed venture capital | 0.922<br>0.916<br>0.893<br>0.805 | 0.920 | 68.874 | 0.935 | 2,008.239 | 45 | 0.000 |
| 2 | Standards-Based Regulatory Support | • Standards setting<br>• Regulation<br>• Labour mobility (law, incentives)<br>• ICT access<br>• Government procurement | 0.993<br>0.992<br>0.670<br>0.649<br>0.603 | 0.917 | 7.278 | | | | |
| | | | | | 76.151 | | | | |

Residuals are computed between observed and reproduced correlations. There are 12 (26.0%) non-redundant residuals with absolute values greater than 0.05.

***Table 9.19** – Latent Factors to Policy Success (Government)*

| Government Respondents (GOV) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Name of Factor | Variables | Factor Loading | Cronbach's Alpha | Total Variance Explained (TVE)% | KMO | Bartlet's Test of Sphericity | | |
| | | | | | | | Chi Squared | Df | |
| 1 | State Support | • Government procurement<br>• Donor funds<br>• Government-backed venture capital | 1.012<br>0.798<br>0.689 | 0.860 | 56.610 | 0.797 | 278.605 | 45 | 0.000 |
| 2 | ICT Infrastructure Support | • ICT access<br>• Standard setting<br>• Regulation | 0.945<br>0.780<br>0.616 | 0.846 | 12.604 | | | | |
| 3 | Monetary & Fiscal Incentives | • Subsidised loans<br>• Tax breaks<br>• Research grants | 0.930<br>0.880<br>0.878 | 0.880 | 8.766 | | | | |
| | | | | | 79.980 | | | | |

Residuals are computed between observed and reproduced correlations. There are 16 (35.0%) non-redundant residuals with absolute values greater than 0.05.

***Table 9.20** – Latent Factors to Policy Success (Medium and High-Tech Industry)*

| Medium and High-Tech Industry Respondents (MHTI) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Number of Factor | Name of Factor | Variables | Factor Loading | Cronbach's Alpha | Total Variance Explained (TVE)% | KMO | Bartlet's Test of Sphericity | | |
| | | | | | | | Chi Squared | Df | Significance |
| 1 | Monetary & Fiscal Support | • Research grants<br>• Government-backed venture capital<br>• Tax breaks<br>• Subsidised loans<br>• Donor funds | 0.996<br>0.953<br>0.888<br>0.848<br>0.696 | 0.956 | 70.678 | 0.902 | 622.289 | 45 | 0.000 |
| 2 | Standards-Based Regulation | • Standards setting<br>• Regulation | 0.902<br>0.799 | 0.912 | 12.009 | | | | |
| 3 | Labour Skills FLow | • Labour mobility (laws, incentives)<br>• ICT access<br>• Government procurement | -0.844<br>-0.420<br>-0.659 | 0.910 | 4.655 | | | | |
| | | | | Cumulative Total (TCVE) | 87.342 | | | | |

Residuals are computed between observed and reproduced correlations. There are 6 (13.0%) non-redundant residuals with absolute values greater than 0.05

***Table 9.21** – Latent Factors to Policy Success (Knowledge-Based Institutions)*

| Knowledge-Based Institution Respondents (KBI) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Name of Factor | Variables | Factor Loading | Cronbach's Alpha | Total Variance Explained (TVE)% | KMO | Bartlet's Test of Sphericity | | |
| | | | | | | | Chi Squared | Df | |
| 1 | Monetary & Fiscal Support | • Subsidised loans<br>• Tax breaks<br>• Government-backed venture capital<br>• Research grants<br>• Labour mobility (laws, incentives) | 0.907<br>0.894<br>0.802<br>0.683<br>0.595 | 0.928 | 71.477 | 0.936 | 1,178.017 | 45 | 0.000 |
| 2 | State Support | • Donor funds<br>• Government procurement | 0.737<br>0.593 | 0.816 | 6.683 | | | | |
| 3 | ICT Infrastructure Support | • Standard setting<br>• ICT access<br>• Regulation | -0.900<br>-0.870<br>-0.850 | 0.926 | 4.894 | | | | |
| | | | | | 83.054 | | | | |

Residuals are computed between observed and reproduced correlations. There are 9 (20.0%) non-redundant residuals with absolute values greater than 0.05.

Based Regulatory Support>. Factor 1 accounts for 68.874% total variance explained and is 9.5 times more powerful than Factor 2. Close scrutiny of factors influencing policy instruments, from each Actor's perspective, shows that direct support either in terms of monetary and fiscal support, or state support is seen as a means to galvanise the effective and efficient performance of the GNSI.

For GOV Respondents Factor 1 <State Support> accounts for 56.61% of TVE, and is responsible for all the variation in the variable 'Government Procurement'. This factor is 4.5 times more powerful than Factor 2, and 6.5 times more so than Factor 3. In examining Factors 1, 2 and 3, it can be appreciated that GOV Respondents assess direct interventions as more crucial in comparison to incentives. Interestingly, the variable 'Labour Mobility (Laws, Incentives)' does not load on any of the factors. For MHTI Respondents, Factor 1 <Monetary and Fiscal Support> accounts for 70.678% of TVE and is responsible for 99.2% of the variation of the variable 'Research Grants', and 90.8% of the variation of the variable 'Government-Backed Venture Capital' in the sample and population. Factor 1 is about six times more powerful than Factor 2 and 15 times more powerful than Factor 3. Factor 1 <Monetary and Fiscal Support> reflects the assessment of the factor barriers to innovation by MHTI which are <Organisational Risks> and <Deficient Fiscal Policy> and influence risks and cost variables of innovation.

For KBI, Factor 1 <Monetary and Fiscal Support> accounts for 71.477% of TVE and is responsible for 82.3% of the variation of the variable 'Subsidised Loans' in the sample and population. Factor 1 is nearly 11 times and 15 times more powerful than Factor 2 and 3, respectively. KBI and MHTI assessment of policy success factors are convergent.

From the individual Actor's assessment, respectively, Factor 1 far outweighs the other factors. Such a view of Factor 1 across GNSI Actors permits a focus on policy implications and recommendations.

The policy implications that arise are: (i) two key dimensions of policy craft <<Financial>> and <<Regulatory>> conform the combination of policy instruments in terms of fiscal, monetary, regulation and performance requirements[117]; (ii) <Fiscal and Monetary Support> to the Actors in the GNSI needs to be recalibrated in the light of systemic failure of policy instruments identified earlier; (iii) <Standards Based Regulatory Support> needs to be recalibrated to sustain the performance of the GNSI; (iv) in return for providing explicit, enshrined in law, support Government would need to demand that GNSI Actors meet performance requirements that are encouraged by incentives and sanctions; (v) MHTI and KBI Respondents are convergent in their assessment of <Monetary and Fiscal Support> being the most significant factor in the success of policy; and, (vi) a judicious policy mix of direct and indirect support measures is requisite.

The policy recommendations to support the <<Financial>> and <<Regulatory>> dimensions of policy success include: (i) selecting a mix of financial instruments (backed to differing extents by Government)[118]; (ii) selecting a mix of tax incentives[119] ; (iii) using a sovereign wealth fund (expected from oil exports) to support direct financial interventions; (iv) selecting a mix of demand-side instruments (public procurement[120], standards setting, regulations, lead markets) to drive policy success; (v) adopting regulations, especially environmental, that use performance and technology based rules; (vi) adopting regulatory incentives for incremental improvements; and, (vii) setting standards oriented toward consumer protection.

**Survey Analysis:** Policy success is determined by a judicious mix of direct and indirect measures.

**Policy Implication:** Recalibration of policy instruments towards performance based measures.

**Policy Recommendation:** Audit the current policy mix for fitness-for-purpose.

[117] This is consistent with the empirics of financing innovation. See OECD (2005) Innovation Policy and Performance: a Cross-Country Comparison; OECD (2012) Science, Technology and Industry Outlook.

[118] Loans, grants, subsidies, venture capital, tax incentives.

[119] R&D tax allowance (concession to a percentage of R&D expenditure), payroll tax credit (reduction in rate of tax), differentiation between large MHTI and SMEs in MHTI firms with SMEs benefitting disproportionately from R&D tax incentives, and targeting of incentives (for example triangulation, start-ups).

[120] For example green public procurement.

# 10.0 Policy Recommendations Matrix

| Policy Implication | Specific Implications | Policy Recommendations |
|---|---|---|
| **Research Institutions' Linkages with the Production System and Level of Innovativeness of Business Enterprises** | | |
| Little or no externalities from the public goods of funding RI | i. there are very few, or no externalities from the public goods support to RIs;<br>ii. signalling mechanisms by which RIs respond to the market, the production system, and BEs are intermittent, or dysfunctional;<br>iii. sales and marketing orientation of RI's intellectual property is poor, and therefore exploitation of knowledge is very limited;<br>iv. flows of intellectual property to the production system are stymied; and<br>v. potential to earn patent, license and royalty fees are unrealised. | i. reform governance of funding measures to RIs and KBIs ;<br>ii. shift funding of RIs and KBIs to performance-based funding as a function of RIs and KBIs engagement with MHTI (collaborative research, product development, Licensing, Patent and Royalty fees (LPRs), and provision of technological development services to MHTI);<br>iii. re-orient funding of RIs and KBIs to competitive grants tied to RIs and KBIs – MHTI relationships;<br>iv. require RIs and KBIs to create intellectual property rights (IPRs) management offices funded on performance;<br>v. require STEMIT doctoral and post-doctoral studies funded by government scholarships to be embedded in MHTI;<br>vi. create fiscal and monetary incentives for MHTI to hire and embed STEMIT post-graduates and doctoral and post-doctoral studies;<br>vii. allow RI and KBI researchers to commercialise discoveries through amended contract conditions;<br>viii. increase management autonomy of RIs and KBIs and the autonomy to their relationship to MHTI;<br>ix. require boards of RIs and KBIs to include CEOs from MHTI;<br>x. set funding of RIs and KBI research programmes within a framework of competitive grants based on triangulation (KBI-RI-MHTI consortia);<br>xi. create a STEMIT Human Capital Mobility Fund; and<br>xii. reform all STEMIT curricula to include an industry placement component. |
| **Actor Importance and Government [GOV] [ISTC] Inter- Intra-Actor Linkages** | | |
| Truncated linkages at best, at worst no idea of systemic relationships pertinent to innovation in the economy | i. coordination of GOV funding in STI;<br>ii. STI organisations' stability;<br>iii. institutionalising evidence-based policy making;<br>iv. evaluation of the mix of policy instruments; and<br>v. catalysing higher networking GNSI densities. | i. MoTI and MEST should become superordinated as the primary formulator and coordinator of all GNSI policy and strategy through a statutory inter-ministerial GNSIPU chaired by the two ministers and reporting to cabinet;<br>ii. GNSIPU should have oversight of, and responsibility for, NSI monitoring, evaluation and assessment of GNSI Actors' performance;<br>iii. establish a GOV sponsored biennial standing conference on 'Innovation and Innovativeness in the National Economy' involving all GNSI Actors;<br>iv. GNSIPU mandated with setting priorities, defining national (and regional) policy, and budget;<br>v. Government policy makers formally consults all GNSI Actors ; and<br>vi. establish a formal consultative process (six monthly) between GNSIPU and MHTI, KBIs and ARBs |

| Policy Implication | Specific Implications | Policy Recommendations |
|---|---|---|
| Actor Importance and Medium and High-Tech Industry [BE] Inter- Intra-actor Linkages | | |
| Business Enterprise (MHTI) isolation leaves them far removed from the policy making process, particularly articulation and calibration of policy to industry needs. | i. role in setting public procurement policy;<br>ii. encouraging cooperation and collaboration between ISTC and industry associations;<br>iii. prominence in the overall governance of the GNSI);<br>iv. projecting to GOV the factor constraints to innovation;<br>v. reviews of regulatory regimes with respect to innovation;<br>vi. removal of obstacles and impediments to public private-sector partnerships; and<br>vii. being convergent with GOV priorities. | i. condition the management of indirect and direct support to Business Enterprises to their engagement with GNSI Actors;<br>ii. institutionalise Business Enterprises in the policy governance of the GNSI through formal consultative processes;<br>iii. reconfigure public procurement policy to require pre-qualification to tender based on inter-linkages (MHTI-KBI);<br>iv. recalibrate sector support to require formal collaborative arrangements between MHTI and public sectors, KBIs and ARBs;<br>v. incentivise Industry Associations and Chambers of Commerce to create liaison offices that deal with KBIs, ARBs and GOV; and<br>vi. incentivise mobility of personnel between private and public sectors using STEMIT Human Capital Mobility Fund. |
| **Actor Importance and Knowledge-Based Institutions [HE][RI] Inter- Intra-actor Linkages** | | |
| Knowledge–Based Institutions, at best poorly connected, and at worst unable to tap into, and exploit, stocks and flows of knowledge. | i. research and development networks;<br>ii. managing the supply-side of advanced human capital resources and DISK to MHTI;<br>iii. responding to the demand-side of human resource requirements from MHTI;<br>iv. specialisation;<br>v. inter-HE institutional competitiveness;<br>vi. pedagogic and curricula programme developments that serve GNSI Actors;<br>vii. alignment of competitive enhancement of KBIs with regional development; and<br>viii. strategic development of KBIs own capacities and capabilities. | i. eliminate regulations and contractual obligations that prevent KBI STEMIT personnel from participating in industry R&D;<br>ii. use the STEMIT Human Capital Mobility Fund to incentivise movement of KBI personnel to Government, MHTI and ARBs and vice versa;<br>iii. require KBIs to hold annual 'open' days with MHTI and ARBs;<br>iv. require KBIs in concert to host a biennial Standing Conference on 'the role of Knowledge-Based Institutions in innovation involving MHTI, ARBs and GOV;<br>v. move sequentially from block grants towards competitive funding for KBIs based on performance;<br>vi. require KBI STEMIT departments to conduct technology foresight exercises with MHTI, ARBs and GOV;<br>vii. evaluate KBI performance for R&D 'top up' grants on triangulation, STEMIT inter-departmental collaboration and academic–industry co-operation indicators;<br>viii. require KBIs to create, IPR offices, and MHTI liaison offices;<br>ix. require KBI STEMIT curricula redesign in consulation with MHTI; and<br>x. reform the academic recruitment policy to enable MHTI practitioners and executive to teach in STEMIT programmes, and permit sabbaticals in MHTI by STEMIT academics. |
| **Actor Importance and Arbitrageur [ARB][FI] Inter- Intra-Actor Linkages** | | |
| Arbitrageurs are severely limited in their role in intermediation. | i. isolated from the primary sources of DISK - and severely limited in intermediation;<br>ii. debilitated in linking ISTC to BEs; and<br>iii. occluded from increasing the technological capacity of BEs. | i. condition indirect and direct support to the capital and financial industry on Arbitrageur engagement with MHTI, KBIs and ISTC;<br>ii. use direct support to match venture capital, private equity investments in KBI 'spin-offs' and incubator projects; and<br>iii. recalibrate the tax code to permit private equity and venture capital investments in KBI and MHTI R&D activities to be written off against profits. |
| **Importance of GNSI Actor and Strength of Actor-Centric Linkages** | | |
| Nexus of innovation policy and industrial innovation absent from the GNSI model. | i. insufficient information exchange between MHTI and KBIs with respect to KBI-GOV relations;<br>ii. ARBs play no significant intermediating role in knowledge transfers regarding IPRs;<br>iii. ARB intra-linkages, have very few (if any) significant externalities;<br>iv. absence of reciprocating communications, coordination and exchange functions;<br>v. operative high-performance councils on Science, Engineering Technology and Innovation, economic and social research, and the 'knowledge brokering' role of ARBs;<br>vi. ARBs prevented from adding value to DISK;<br>vii. [BE]ARB-BE linkage has less depth than otherwise in the absence of ARB access to DISK; | i. initiation of formal consultative process on innovativeness and innovation in the national economy involving GOV, MHTI, KBIs, ARB;<br>ii. ensure accountability standards, managerial requirements and governance structures are harmonised across KBIs (RI, HE);<br>iii. eliminate constraints preventing public sector institutions from engaging in STEMIT activities in the private sector;<br>iv. adopt common performance agreements (linked to funding) with external relationship indicators, across KBIs (RI, HE);<br>v. dissolve poor performing RIs, merging middling-performance RIs and selectively corporatizing high-performance RIs;<br>vi. create SETIRC chaired at vice-presidential level;<br>vii. adopt an open to all centralised KBI Information Reporting System;<br>viii. adopt advanced monitoring and evaluation practices for evidence-based assessment of KBIs and policy instruments (UNIDO methodology); |

| Policy Implication | Specific Implications | Policy Recommendations |
|---|---|---|
| | viii. ARBs unable to convincingly persuade GOV towards policies that enhance stocks and flows of knowledge;<br>ix. very low returns from the expenditure;<br>x. externalities extremely limited thus reducing effectiveness and efficiency of the GNSI;<br>xi. GOV framework of incentives for KBIs mostly ineffective in that GOV demands little from KBIs in return for providing financial support;<br>xii. GOV supported ISTC inter-linkages with KBIs largely ineffective;<br>xiii. performance required from KBIs by GOV is limited or has no dimensions that encourage KBIs to engage proactively with GNSI Actors;<br>xiv. need for recalibration of STEMIT under- and post- graduate courses to needs of MHTI;<br>xv. reconfiguring the national service programme towards internships in MHTI for STEMIT students;<br>xvi. conditioning financial support (research 'top up' grants etc.) on joint research with MHTI;<br>xvii. redesigning final year undergraduate and postgraduate projects in STEMIT to be inter-disciplinary to address a specific local problem in order to seed, and initiate, the potential for graduates to create their own employment;<br>xviii. truncated relations with demand and factor markets;<br>xix. VI-VW KBI passive [HE]BE-HE inter-linkages;<br>xx. stocks of KBI IPRs find little or no receptive outlets either in ISTC or MHTI;<br>xxi. performance requirements from RI and ISTC are very limited;<br>xxii. conspicuous gaps in GOV-MHTI and ARB-KBI (and vice versa) linkages;<br>xxiii. policy levers available to GOV are, at best, articulated insufficiently well and at worst too remote for effective policy craft and efficient policy direction; and<br>xxiv. limited ability of GOV to enforce policy with respect to KBI-ARB inter-linkages | ix. accelerate and elevate the strategy for e-Government;<br>x. perform an audit of the policy mix of instruments and incentives aimed at increasing innovativeness;<br>xi. reconfigure public sector procurement to require triangulation between MHTI, KBIs and ARBs;<br>xii. use regional development funds to triangulate regional government, industry associations and KBIs to develop clusters;<br>xiii. ensure MHTI, KBIs and ARB representation on the SETIRC; and<br>xiv. adapt the FDI regulatory regime to favour business collaboration and R&D joint ventures between foreign investors, MHTI and KBIs. |
| **Government [GOV][ISTC] Inter- Intra-Linkages – Level of Innovativeness of Business Enterprises** | | |
| Lack of policy mapping of GNSI for policy monitoring and evaluation. | i. GOV not having ready-at-hand means and instruments to map and measure the GNSI;<br>ii. GOV isolation from GNSI (presents a serious challenge to Government efforts in creating a higher performance NSI);<br>iii. ICT competition and broadband internet neither produces externalities that translate into advantages that benefit the GNSI nor generates directly innovativeness in BE;<br>iv. GOV's ability to manage the conflictual/ co-operation balance between Actors, institutions and organisations doubtful;<br>v. innovation policy coordination subject to higher levels of uncertainty than would be otherwise with the availability of comprehensive 'road maps' of the GNSI;<br>vi. achieving convergence in innovativeness with other frontier EMEs extremely difficult;<br>vii. GOV's ability to orchestrate the strategic coherence of the GNSI is vague;<br>viii. GOV tends to perceive its role as a recipient of resource solicitations, and GOV outreach is limited;<br>ix. Government command over the environment for innovation insufficient; | i. SETIRC and GNSIPU to strategise and prioritise a MHTI-centred innovation system by legislatively allocating 2% of GDP for public expenditure support to the science and technology sector;<br>ii. require KBIs (RIs) to instigate fora of dialogue on R&D agendas with MHTI, and Government; |

| Policy Implication | Specific Implications | Policy Recommendations |
|---|---|---|
| | x. GOV may not be leveraging its legislative power sufficiently to increase the level of higher resolution standards;<br>xi. policy environment may be insufficiently calibrated by Government;<br>xii. role of Government, as the prime driver of the economy, is not fully utilised in encouraging innovativeness and innovation;<br>xiii. very weak Government linkages mutes the policy dialogue between GNSI Actors; and<br>xiv. GOV-BE links are neither resulting in high innovation. | iii. adoption of the UNIDO methodology for surveying NSI for longitudinal monitoring, assessment and evaluation; and<br>iv. the GNSIPU to streamline the regulatory environment for STEMIT by auditing regulations. |
| **Business Enterprises [MHTI] Inter- Intra-Linkages - Level of Innovativeness of Business Enterprises** | | |
| Innovation is primarily manifest in industry (supply-side) and markets (demand-side), however BE isolation means little access to other sources of knowledge. | i. MHTI has little, if any, access to sources of innovation other than its own research and development expenditure and efforts;<br>ii. exposure of BEs to DISK is reduced;<br>iii. regulatory dynamic for increasing standards and competition is lethargic;<br>iv. opportunities to leverage and synergise BE R&D with that in RIs are severely limited;<br>v. identification of 'promising local companies' and potential 'national champions' is obscured;<br>vi. market signals with respect to demand are unnoticed; and<br>vii. opportunities for generating externalities through cross-cutting licensing and patenting and concomitant fees are limited. | i. preferential tax rate for MHTI as a function of triangular (MHTI-KBIs-ARB) R&D, joint product development, and sub-contracting relations;<br>ii. address barriers to innovation identified;<br>iii. identify SMEs that are 'promising local companies' in MHTI and assisting them to grow;<br>iv. initiate a 'commercialisation and marketing framework' in tandem with the promising local companies programme;<br>v. configure, as part of the Government venture capital system, a Technology Commercialisation Fund (TCF), access to which requires triangulation (MHTI-KBI-ARBs); and<br>vi. perform an analysis of FDI spillovers to MHTI and adjust the FDI regime to enhance spillovers and externalities. |
| **Higher Education [KBI] Inter- Intra-Linkages - Level of Innovativeness of Business Enterprises** | | |
| KBIs have highly restricted outlets through intermediation and commercialization, to demand markets; poor market intelligence; and are insufficiently aware of market needs. | i. KBI DISK do not have outlets, through intermediation and commercialisation;<br>ii. KBI (HE) have poor market intelligence capacity and capability;<br>iii. management of the KBI IPRs system is remote from users [MHTI (BEs)] and intermediators [ARB (FI)];<br>iv. curricula redesign with an increased emphasis on industrial placements is hampered;<br>v. research is tangential to the needs of MHTI;<br>vi. opportunities for industry funded and sponsored R&D, as well as product development, leading to incubation of spin-offs (in high technology) into SMEs are truncated; and<br>vii. opportunities for fund raising are limited. | i. adopt a competitively incentivised IPR management system for KBIs that disproportionately rewards KBIs with the highest STEMIT IPR performance (LPRs and industrial contracts);<br>ii. recalibrate funding of post-graduate studies to favour R&D in STEMIT programmes;<br>iii. provide incentives for STEMIT post-graduates to work in the private sector;<br>iv. redesign STEMIT post-graduates courses and programmes to require one year placement in a MHTI firm where part of the research is performed;<br>v. reconfiguration of the public service entrance and promotion examinations system to link to STEMIT and management courses and programmes in KBIs; and<br>vi. incentivise MHTI to write off against profits industry funded and sponsored R&D that takes place under contract in KBIs. |
| **Research Institutes [KBI] Inter- Intra-Linkages - Level of Innovativeness of Business Enterprises** | | |
| Strategic research and development operations misaligned with the needs of MHTI specifically and that of the market in general. | i. there is at best a solitary role and at worst a dysfunctional role of RIs in the GNSI;<br>ii. RIs (strategic) research and development divergent from needs of MHTI;<br>iii. even if RIs DISK transmission mechanisms have potential, the almost complete isolation of ARB from the GNSI implies truncation as the financial framework for commercialisation is missing to a large extent;<br>iv. absence of a sales and marketing disposition on the part of RIs;<br>v. opportunities for funding, sponsorship and R&D joint ventures with MHTI are severely limited;<br>vi. opportunities for human capital mobility between RIs and MHTI truncated; and<br>vii. research agendas of RIs divergent from market demands. | i. submit RIs to external international review by bodies such as UNIDO, OECD, and South Africa's National Advisory Council on Innovation (NACI);<br>ii. recalibrate RI human resources policy to enable RI staff to perform their research in MHTI;<br>iii. reconfigure Government procurement of services from RIs to require triangulation; and<br>iv. reconfigure GOV funding support to RIs to be contingent on matching funds. |
| **Arbitrageurs Intra- Inter-Linkages - Level of Innovativeness of Business Enterprises** | | |
| Stocks of knowledge are unexposed and flows of DISK are glacial at best and nonexistent at worst. | i. stocks of knowledge remain unexposed;<br>ii. very weak GOV-ARB inter-linkages imply limited ability of ARBs to influence innovation policy;<br>iii. ARBs unable to exploit the competitive advantages that arise from information asymmetries;<br>iv. ARBs cut off from taking equity positions in either potential start-up businesses either based on KBI R&D outputs or spin-offs from KBI and MHTI; and<br>v. crucial role of linking the GOV-KBI and KBI-MHTI axes of the Triple Helix type 4 is largely missing. | i. decide a strategy for expanding the size of the capital and financial market ;<br>ii. condition fiscal and monetary, as well as regulatory and performance incentives to the finance capital industry on the intermediation role of ARBs with respect to KBIs and MHTI;<br>iii. use Government-Backed Venture Capital to match equity positions by ARBs in technology incubation programmes in KBIs;<br>iv. require KBI development of science and technology parks to have 'anchor' tenants from finance capital industry;<br>v. use the STEMIT Human Capital Mobility Fund to support mobility of personnel in finance capital to teach in KBIs (sabbaticals);<br>vi. map the structure of early stage financing of innovation and entrepreneurship;<br>vii. restructure Government-Backed Venture Capital into separate funds relevant to stages of innovation and entrepreneurship;<br>viii. enable (through tax incentives) high net worth individuals to invest directly in start-ups or in venture capital funds. |

| Policy Implication | Specific Implications | Policy Recommendations |
|---|---|---|
| Barriers to innovation to be tackled economy-wide as well as in terms of actor-specific interventions. | **Latent Factors to Barriers to Innovation - ALL** | |
| | Overall, the key policy implication is that without threshold levels in Skills-ICT Capability/Capacity economy-wide innovativeness and innovation is extremely difficult to attain.<br><br>i. in resource constrained circumstances, the crucial choice is where fiscal and monetary incentives, regulation and performance requirements, should be directed to enhance the Skills-ICT Capability/ Capacity, through improving the 'Quality of Technically Trained Manpower' and the 'Rate of Access to ICT';<br>ii. the four factors have different temporal characteristics in terms of policy action;<br>iii. F1 <Skills-ICT Capability/Capacity > is relatively short term (1-3 years) given the capacity aspect of ICT;<br>iv. F2 <Unsophisticated Markets> and F3 <Deficient Fiscal Policy> are medium-term (3-5 years) given the legislative aspect of fiscal policy;<br>v. F4 <Reduced Organisational Risks> is long term (5-10 years) given the organisational behavior aspects and the need to change institutional behavior; and<br>vi. all factors are important and have to be addressed by Government policy on innovation. | Policy recommendations to address deficiencies in <<Organisational Capital>>:<br><br>i. recalibrating curricula reform to the needs of MHTI;<br>ii. reorient the quantity and quality of secondary and tertiary education, vocational training as well as enterprise-based training towards STEMIT and management;<br>iii. increase fiscal and management autonomy of KBIs conditioned on joint training programmes with MHTI such that STEMIT courses are increasingly grounded in business enterprises;<br>iv. upgrade the information infrastructure to enable ICT diffusion in 'super corridors' and 'super region';<br>v. reduce ICT network costs;<br>vi. upgrade the ICT information infrastructure specifically for KBIs (a high-speed national research and education network to link all universities, Government agencies and RIs); and<br>vii. to mitigate the brain drain by GOV direct sponsorship of rolling National Development Conferences to network the diaspora and local entrepreneurship.<br><br>Policy recommendations to address the insufficiencies in <<Market Demand>>:<br><br>i. use standards based regulation and performance requirements to force firms towards technological adaptation;<br>ii. use standards setting and regulation in the managerial accounting domain for accelerated depreciation of capital;<br>iii. reconfigure public procurement terms and conditions towards innovativeness;<br>iv. from a product/technology 'push' perspective, strengthen incentives for commercialisation of publicly funded R&D at KBIs; and<br>v. initiate a patent management corporation to co-ordinate the commercialisation of IPRs.<br><br>Policy recommendations to address <<Organisational Constraints>>:<br><br>i. reconfigure business regulation to reduce the number of processes, the length of time, the cost to start a business through analysis of bottlenecks and costs;<br>ii. eliminate bottlenecks in granting of permits and securing access to power;<br>iii. speed up the procedures to register property (and hence ability to collateralise assets);<br>iv. use Government-Backed Venture Capital to ease access to credit for entrepreneurship;<br>v. ensure protection of investors through the courts;<br>vi. recalibrate the tax regime to favour entrepreneurship and innovation;<br>vii. reduce barriers to cross-border trade (documentation, etc.);<br>viii. reduce the cost of contract enforcement;<br>ix. reduce the time to resolve insolvency in order to accelerate business entry and exit dynamics;<br>x. initiate a programmatic co-ordination of support to innovation that has at its core performance of regular, independent evaluations with international comparators; and<br>xi. initiate a programme to enhance the technology absorptive capacity and capability of SMEs in MHTI . |
| | **Latent Factors to Barriers to Innovation - Government**<br><br>i. funds should be directed to improve Skills-ICT Capability and Capacity, through explicit policy support to improving the quality of 'Technically Trained Manpower' and addressing the 'Lack of Technically Trained Manpower';<br>ii. increasing the resolution of standards through 'Standard Setting';<br>iii. in order for markets to meet the higher standards they are forced to become more adaptive and innovative;<br>iv. policy instruments ('Standards Setting,' 'Regulation' and 'Government Procurement') are not successful;<br>v. three particular policy instruments ('Standards Setting,' 'Regulation' and 'Government Procurement') need to be recalibrated and re-conformed; and<br>vi. without adequate human capital, economy-wide innovativeness and innovation is virtually impossible to achieve. | |
| | **Latent Factors to Barriers to Innovation – Medium-High Tech Industry**<br><br>i. GOV and MHTI need to engage in a standing dialogue to align priorities through targeted policy;<br>ii. compliant with WTO obligations, MHTI should be enabled to take advantage of explicit policy support; and<br>iii. the 'central nervous system' of the economy – the ICT network capacity and related skills capability – needing to be seriously upgraded; | |

| Policy Implication | Specific Implications | Policy Recommendations |
|---|---|---|
| Barriers to innovation to be tackled economy-wide as well as in terms of actor-specific interventions. | **Latent Factors to Barriers to Innovation – Knowledge-Based Institutions** | |
| | i. KBI view of Factor 2 "Sophisticated Markets" does not converge with the view of ALL respondents, GOV respondents, and MHTI respondents;<br>ii. Even if KBIs wish to commercialise DISK due to their very weak or nonexistent linkages they find no reception in the market;<br>iii. KBIs are far from fully reorienting their role towards corporate entrepreneurship in which they exploit and commercialise DISK; and<br>iv. GOV's 'arm's length' relationship with KBIs, with respect to innovativeness and innovation performance requirements tends to preclude adaptive behaviour by KBIs. | Policy recommendations to address <<Fiscal and Monetary Deficiencies>>:<br>i. audit of MHTI to identify early adopters and early majority firms as promising local companies in the diffusion of innovation paradigm;<br>ii. align funding, fiscal and monetary support to promising local company performance; and<br>iii. recalibrate the corporate tax regime to reduce innovation costs. |
| Success of Policy Instruments and Barriers to Innovation | | |
| Poorly configured and inadequately calibrated policy instruments and interventions. | i. the two primary policy instruments – Government-Backed Venture Capital – and – ICT Access – (once recalibrated) are strategically crucial to addressing and overcoming the systemic deficits in the <<Organisational Capital>>;<br>ii. the policy instruments – Subsidised Loans, Regulation, Standards Setting, and Labour Mobility (Laws, Incentives) – (once recalibrated) are operationally crucial to addressing and overcoming the system-wide <<Organisational Constraints>>; and<br>iii. three major specific barriers to Innovation variables namely: 'Lack of Explicit Policy Support', 'Innovation Costs (too high)', and 'Excessive Perceived Economic Risk' need to be the target of focused attention of policy prescription and instruments. | Five areas of policy recommendations are:<br>1. With respect to an innovation economy:<br>i. develop a customised innovation policy with quantitative targets;<br>ii. use peer (middle income country) innovation metrics to track and measure policy progress and effectiveness using UNIDO methodology;<br>iii. embed a culture of innovation across the management of the economy;<br>iv. orient policy to address the key barriers to innovation facing the national economy; and<br>v. create a departmental unit in the Ministry of Education (Department of KBI Skills and Innovation – (KBISI)) that, along with the SETIRC and the GNSIPU, ensures innovativeness across GNSI Actor behaviour.<br>2. Regarding public procurement and innovation:<br>i. deploy the weight of GOV spending power, public procurement and public services demand to reconfigure the environment for innovation and innovativeness;<br>ii. require all Government departments to develop an innovation procurement plan;<br>iii. GNSIPU and Dept. KBISI to facilitate mobility of private sector personnel into the public sector;<br>iv. use Government procurement to create 'lead markets' for innovative products and services;<br>v. GOV to have a posture of an 'early adopter' in the diffusion of innovation paradigm;<br>vi. consolidate public procurement Authority, Agency, Board into a new Government Procurement Service; and<br>vii. open up procurement windows for SMEs in MHTI.<br>3. Regarding business incubation:<br>i. GOV as a user of products and services, along with KBIs, to focus on SMEs in MHTI;<br>ii. KBIs to be required to create business incubators into which is fed the results of STEMIT research at masters, doctoral and post-doctoral research;<br>iii. differentiate GOV support to entrepreneurship much more finely in terms of fiscal/final, managerial and technological levels; and<br>iv. leverage Government-Backed Venture Capital with private sector and Arbitrageur funding of incubators. |

| Policy Implication | Specific Implications | Policy Recommendations |
|---|---|---|
| | | 4. Regarding STEMIT as the prime drivers of innovation:<br><br>i. achieve the GOV target of 1% of GDP to support STEMIT, then doubling to 2% of GDP within three years;<br>ii. leverage private R&D expenditure through fiscal recalibration, matching funds and direct support;<br>iii. require all public expenditure on STEMIT programmes to generate patent, licensing and royalty fees;<br>iv. initiate a specific KBI Innovation Fund to support STEMIT spin-offs from KBI research;<br>v. require KBIs to perform STEMIT research, pedagogy, knowledge transfer (to/from industry), act as national and regional conduits into the global knowledge economy, and lead in the design and delivery of regional economic development strategies, against performance-based targets;<br>vi. reorient education towards life-long learning, STEMIT and for innovation; and<br>vii. adopt a geo-spatial information systems (GSIS) approach to policy making.<br><br>5. Regarding absorbing international innovation:<br><br>i. focus on connecting the urban centres in the super region of Ashanti-Eastern-Greater Accra;<br>ii. require KBIs to develop international partnerships;<br>iii. measure KBIs on their absorptive capacity;<br>iv. require GNSI Actors to collaborate as a function of Government support; and<br>v. Government to fund KBI R&D on the basis of inter-disciplinary collaboration and triangulation. |
| **Availability of Policy Instruments & Success** | | |
| Need to recalibrate fiscal and monetary policies to make Tax Breaks, Government-Backed Venture Capital, and Subsidised Loans effective. | i. fiscal (and monetary) policy needs recalibrating, consistent with WTO provisions of non-actionable subsidies; and<br>ii. the policy instruments that require most urgent recalibration to address and overcome barriers to innovation are: Fiscal (Tax Breaks), Subsidised Loans, and Government-Backed Venture Capital. | i. R&D tax credits, as an incentive for business R&D rates of relief to be adjusted upwards for SMEs in MHTI;<br>ii. reductions in the wage taxes of R&D personnel in KBIs and MHTI;<br>iii. initiate a STEMIT research tax incentive programme;<br>iv. initiate a STEMIT business scholarship programme for post-doctoral researchers to commercialise their research;<br>v. recalibrate tax treatment of share options for spin-offs and start-ups to attract experienced managers; and<br>vi. use Government-Backed Venture Capital to guarantee loans. |
| **Latent Factors to Policy Success** | | |
| Recalibration of policy instruments towards performance based measures. | i. two key dimensions of policy craft <<Financial>> and <<Regulatory>> conform the combination of policy instruments in terms of fiscal, monetary, regulation and performance requirements;<br>ii. <Fiscal and Monetary Support> needs to be recalibrated in the light of systemic failure of policy instruments identified;<br>iii. <Standards Based Regulatory Support> needs to be recalibrated to sustain the performance of the GNSI;<br>iv. in return for providing explicit, enshrined in law, support GOV would need to demand that GNSI Actors meet performance requirements that are encouraged by incentives and sanctions; and<br>v. a judicious policy mix of direct and indirect support measures is requisite. | Policy recommendations to address <<Financial>> and <<Regulatory>> dimensions of policy success:<br><br>i. select a mix of financial instruments (backed to differing extents by GOV);<br>ii. select a mix of tax incentives;<br>iii. use of sovereign wealth fund (expected from oil exports) to support direct financial interventions;<br>iv. select a mix of demand-side instruments (public procurement, standards setting, regulations, lead markets) to drive policy success;<br>v. adopt regulation, especially environmental, that uses performance and technology based rules;<br>vi. adopt regulatory incentives for incremental improvements; and<br>vii. Standards Setting oriented to consumer protection. |

## 10.1 Concluding Remarks

The overarching context for the GNSI is the transformation of global economic contours through innovation and inherent implications for the competitive abilities of national economies to deliver sustainable growth for respective citizens. Without serious attention to innovation and innovativeness in the Ghana economy, the country faces the risks of becoming trapped in a low middle-income condition.

The mapping and measurement of the GNSI, the ensuing policy analysis and recommendations provide a base-line for policy action. This would need to be articulated in terms of business plans and managerial actions from, and for, the Actors to implement in accordance with resources available, and direction, from the GoG.

Innovating is crucially important for economic growth and the GNSI should be seen as the lynchpin of industrial policy for Ghana. This is acknowledged in GoG policy documents as analysed in Chapter 8. However, as indicated previously, making the GNSI a high-performance system, understood in terms of a complex adaptive system of interactions, networks and organisational relationships, requires the policy recommendations to be viewed through a 'whole-of-Government' lens.

The comprehensive, but not exhaustive, policy recommendations in this Report should also be seen in the light of likely developments in the future for the policy mix to enhance business R&D and innovativeness[121].
The major developments are:

- Increasing focus on specific targets (sectors, enterprise types, SMEs in MHTI, new technology based firms);
- Greater attention to targeting specific technology areas (ICT, bio-informatics, materials, agri-business, engineering, etc.);
- Expanded use of financial and monetary instruments aimed at reducing the investment costs of innovation;
- Increasing preference for competitive performance-based instruments to select for policy target eligibility; and
- Accelerated shift to supply-side policy instruments to increase DISK and to reap externalities.

To this end, the following framework assists in managing the change in the balance of the policy mix for ensuring that the effective and efficient operation of the GNSI delivers increasing levels of innovation and innovativeness in the economy. Successful policy management of the complex reality of the GNSI requires policy-makers to appreciate, in applying instruments, as well as business plans and managerial actions to Actors, that:

- Leadership is an emergent quality of institutional and personal relationships in the GNSI;
- Managing the dynamics of Actor interactions is preferable to controlling exclusively individual Actors;
- Focusing on Actor contributions is preferable to exercising formal power;
- Placing more weight on multi-lateral dialogue is likely to bring about greater coherence, effectiveness and efficiency of the GNSI;
- With the whole-of-Government approach, the GoG should intensely participate in fostering its GNSI relationships in preference to an "arm's length" position;
- Concentrating on monitoring, assessing, evaluating and exploring the emergent properties of the GNSI is likely to provide greater opportunities to hold Actors to account; and
- Ensuring that, on the one hand, authority and responsibility, and, on the other hand, resources and accountability are not separated in applying policy is the *sine qua non* of effectiveness and efficiency in making the GNSI a high-performance system.

The way forward then is for the GoG, as the prime mover in the economy, to see a fit-for-purpose GNSI as the core of its objectives of industrial policy. As such, with political will and coherent policy instruments (differentiated according to Actor) the GNSI will assist in: overcoming the skills deficit; making the public sector more competitive; tuning the fiscal and tax system to the needs of KBIs and MHTI; drastically reducing barriers between Actors; increasing the attractiveness of the economy for FDI; accelerating the commercialisation of R&D; ensuring ICT becomes the 'central nervous system' of the economy; building infrastructure to serve the innovation economy; and 'greening' the economy.

[121] See OECD, 2012, pp. 156-159.

# 11. References


Aaronson, S.A., 2011. How Empowering Ghanaians Can Help Ghana Avoid an Oily Mess. In: UNIDO (United Nations Industrial Development Organization), *Conference on Competitiveness & Diversification: Strategic Challenges in a Petroleum Rich Economy.* Accra, Ghana 14-15 March 2011. Ch.9.

Adarkwa, K., 2008. Keynote address delivered at the official launching of the Science and Technology Research Endowment Fund. Kumasi: Kwame Nkrumah University of Science and Technology.

Adepoju, A., 2007. Migration in Sub-Saharan Africa. Background Paper Commissioned by the Nordic Africa Institute for the Swedish Government White Paper on Africa.

Allen, P.M., 2000. Knowledge, Ignorance, and Learning. *Emergence*, 2(4), p.85.

Andersson, T. and Napier G., 2007. *The Role of Venture Capital, Global Trends and Issues from a Nordic Perspective*. Malmo: IKED.

Antonelli, C., 1999. The Evolution of the Industrial Organization of Production. *Cambridge Journal of Economics*, 23(2), pp.243–260.

Archibugi, D. and Iammarino, S., 1999. The Policy Implications of the Globalisation of Innovation. *Research Policy*, 28(2-3), pp.317–336.

Asamoah, J., 2011. Strategic Resources and their Management: the Oil Find in Ghana. In: UNIDO (United Nations Industrial Development Organization), *Conference on Competitiveness & Diversification: Strategic Challenges in a Petroleum Rich Economy*. Accra, Ghana 14-15 March 2011. Ch.8.

Asheim, B.T. and Coenen, L., 2004. The Role of Regional Innovation Systems in a Globalizing Economy: Comparing Knowledge Bases and Institutional Frameworks of Nordic Clusters. Working Paper 03/2005. Lund: Centre for Innovation, Research and Competence in the Learning Economy (CIRCLE).

AU–NEPAD (African Union–new Partnership for Africa's Development), 2010. *African Innovation Outlook 2010*. Pretoria: AU-NEPAD.

Avnimelech, G. and Teubal, M., 2003. Israel's Venture Capital Industry: Emergence, Operation and Impact. In: D. Cetindamar, ed. 2003. *The Growth of Venture Capital: a Cross-Cultural Comparison*. London: Praeger.

Avnimelech, G. and Teubal, M., 2005. Evolutionary Innovation and High Tech Policies: What Can We Learn from the Israel's Targeting of Venture Capital? *Science, Technology and Economic Program (SETE)*, Working Paper Series WP-25-2005. Neaman Institute, Technion-Israel Institute of Technology.

Avnimelech, G., 2009. VC Policy: Yozma Program 15-years Perspective. In: DRUID (Danish Research Unit on Industrial Dynamics), *Summer Conference on Innovation, Strategy and Knowledge*. Copenhagen, Denmark 17-19 June 2009.

Bartels, F.L. and Lederer, S., 2009. Changing Patterns in Industrial Performance – A UNIDO Competitive Industrial Performance Perspective: Implications for Industrial Development. Working Paper 05/2009. Vienna: United Nations Industrial Development Organization (UNIDO), Research and Statistics Branch.

Bartels, F.L. Koria, R. and Carneiro, S., 2009. National Systems of Innovation in Selected Emerging Market Economies: an Examination of Actors, Interactions and Constraints. In: EAMSA (Euro-Asian Management Studies Association), 26th *Conference on Globalization of Technology, Innovation and Knowledge*. Lausanne, Switzerland 22-24 Oct. 2009.

Bartels, F.L. Voss, H. Bachtrog, C. and Lederer, S., 2012. Determinants of National Innovation Systems: Policy Implications for Developing Countries. *Innovation Management Policy and Practice*, 14(1), pp.2-18.

Bartels, F.L., 2005. Determinants of National Innovation Systems: Policy Implications for Developing Countries. In: IAMOT (International Association for the Management of Technology), *14th International Conference on Management of Technology*. Vienna, Austria 22-26 May 2005.

Baygan, G. and Freudenberg, M., 2000. The Internationalization of Venture Capital Activity in OECD Countries: Implications for Measurement and Policy. Science, Technology and Industry Working Paper 7/2000. Paris: Organization for Economic Cooperation and Development (OECD).

*Bayh-Dole Act 1980*. Washington, D.C.: USPTO.

Bjørnskov, C. and Svendsen, G.T., 2002. Why Does the Northern Light Shine So Brightly? Decentralisation, Social Capital and the Economy. Working Paper 15/2002. Aarhus: Aarhus School of Business.

Blanc, H. and Sierra, C., 1999. The Internationalisation of R&D by Multinationals: a Trade-off Between External and Internal Proximity. *Cambridge Journal of Economics*, 23(2).

Braadland, T.E. and Anders, E., 2002. Innovation in Norwegian Industries – Testing a New Taxonomy. STEP Report Series 200206. Oslo: The STEP Group.

Buckley, P.J. and Carter, M.J., 2004. A Formal Analysis of Knowledge Combination in Multinational Enterprises. *Journal of International Business Studies*, 35(5), pp.371–384.

Carlsson, B., 2006. Internationalization of Innovation Systems: a Survey of Literature. Research Policy, 35(1), pp.56–67.

Clason, D.L. and Dormody, T.J., 1994. Analyzing Data Measured by Individual Likert-Type Items. *Journal of Agriculture and Education*, 35(4), pp.4-35.

Cohendet, P. et al., 1999. Knowledge Coordination, Competence Creation and Integrated Networks in Globalised Firms. *Cambridge Journal Economy*, 23(2), pp.225-241.

Cortina, J.M., 1993. What is Coefficient Alpha? An Examination of Theory and Applications. *Journal of Applied Psychology*, 78, pp.98-104.

Dosi, G., Freeman, C., Nelson, R.R., Silverberg, G., Soete, L., 1988. *Technical Change and Economic Theory*. London: Pinter.

DRUID (Danish Research Unit for Industrial Dynamics), 1999. *Summer Conference on National Innovation Systems, Industrial Dynamics and Innovation Policy*. Rebild, Denmark 9-12 June 1999.

DRUID (Danish Research Unit for Industrial Dynamics), 2012. *Conference on Innovation and Competitiveness: Dynamics of Organizations, Industries, Systems and Regions*. Copenhagen, Denmark 19-21 June 2012, p.16.

Dunning, J.H., 1997a. *Alliance Capital and Global Business*. London: Routledge.

Dunning, J.H., 1997b. Technology and the Changing Boundaries of Firms and Governments. In: *Industrial Competitiveness and the Global Economy*. Paris: Organization for Economic Cooperation and Development (OECD).

Dunning, J.H., 2000. *Regions, Globalization, and the Knowledge-based Economy*. Oxford: Oxford University Press.

Dutta, S. and Bilbao-Osorio, B., eds. 2012. *The Global Information Technology Report 2012: Living in a Hyperconnected World*. 10: 92-95044-33-9. Geneva: World Economic Forum.

Dziuban, C.D. and Shirkey, E.S., 1974. When is a Correlation Matrix Appropriate for Factor Analysis? Some Decision Rules. *Psychological Bulletin*, 81, pp.358-361.

Easterby-Smith, M. Thorpe, R. and Jackson, P., 2012. Management Research 4th Edition. London: SAGE Publications Ltd.

Edquist, C. and Lundval, B.A., 1993. Comparing Danish and Swedish Systems of Innovation. In: C. Edquist, ed. 1993. *Systems of Innovation, Technologies, Institutions and Organisations*. London: Printer.

Etzkowitz, H., 2002. Incubation of Incubators: Innovation As a Triple Helix of University-Industry-Government Networks. *Science and Public Policy*, 29(2), pp.115-128.

Etzkowitz, H., 2003. Research Groups as 'Quasi-firms': the Invention of the Entrepreneurial University. *Research Policy*, 32, pp.109-121.

Evenson, R.E. and Westphal, L.E., 1995. Technological Change and Technological Strategy. In: J. Behrman and T. N. Srinivasan, eds. 1995. *Handbook of Development Economics, Volume 3A*. Amsterdam: Elsevier, pp.2209-2299.

Foxon, T., Makuch, Z., Mata, M., Pearson, P., 2004. Innovation Systems and Policy-Making Processes for the Transition to Sustainability. In: K. Jacob, M. Binder and A. Wieczorek, eds. 2004. Governance for Industrial Transformation. Proceedings of the 2003 Berlin Conference on the Human Dimension of Global Environmental Change. Berlin: Environmental Policy Research Centre (EPRC), pp.96-112.

Freeman, C. and Louça, F., 2001. *As Time Goes By: From the Industrial Revolutions to the Information Revolution*. Oxford: Oxford University Press.

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

Garland, R., 1991. The Mid-point on a Rating Scale: is it Desirable? *Marketing Bulletin*, 2, pp.66–70. Research Note 3.

Gaur, S., 1997. Adelman and Morris Factor Analysis of Developing Countries. *Journal of Policy Modeling*, 19(4), pp.407-415.

George, D. and Mallery, P., 2003. *SPSS for Windows Step by Step: a Simple Guide and Reference*. 11.0 update. 4th ed. Boston: Allyn & Bacon.

Gordon R. J., 2012. Is U.S. Economic Growth Over? Faltering Innovation Confronts the Six Headwinds. NBER Working Paper No. 18315, August.

Government of Ghana, (2012) Budget [online] Available at: http://danquahinstitute.org/docs/2012%20budget%20print%20latest.pdf [Accessed on 11 October 2012].

Government of Ghana, 2003. *Education Strategic Plan I & II (2003-2015)*. Accra: Ministry of Education.

Government of Ghana, 1995. *Ghana - Vision 2020: the First Step Policy Framework* (1996-2020). Accra: Government of Ghana.

Government of Ghana, 2003. *Ghana Poverty Reduction Strategy (GPRS) I*, 2003-2005. National Development Planning Commission, [online] Available at: <http://siteresources.worldbank.org/GHANAEXTN/Resources/Ghana_PRSP.pdf> [Accessed on 4 April 2012].

Government of Ghana, 2003. *Ghana ICT for Accelerated Development (ICT4AD) Policy*. Accra: Ministry of Communications and Technology.

Government of Ghana, 2005. *Ghana Poverty Reduction Strategy (GPRS) II 2006-2009*. National Development Planning Commission, [online] Available at: <http://planipolis.iiep.unesco.org/upload/Ghana/PRSP/Ghana%20PRSP%20June%202006.pdf> [Accessed on 4 April 2012].

Government of Ghana, 2005. *Ghana Trade Policy*. Accra: Ministry of Trade and Industry.

Government of Ghana, 2005. Ministerial ICT Policy Statements. [online] Available at: http://www.ict.gov.gh/html/ministerial%20ict%20policy%20statements.htm> [Accessed on 8 May 2012].

Government of Ghana, 2008. *Preliminary Education Sector Performance Report 2008*. Accra: Ministry of Education, Science and Sports.

Government of Ghana, 2010. *Education Strategic Plan I & II (2010-2020)*. Accra: Ministry of Education.

Government of Ghana, 2010. *Ghana Shared Growth and Development Agenda (GSGDA I*). Accra: National Development Planning Commission.

Government of Ghana, 2010. *Ghana Shared Growth and Development Agenda (GSGDA II*). Accra: National Development Planning Commission.

Government of Ghana, 2010. *National Science, Technology and Innovation Development Programme of Ghana (STIDEP)* 2011-2015. Accra: Ministry of Environment, Science and Technology.

Government of Ghana, 2011. *Ghana Industrial Policy*. Accra: Ministry of Trade and Industry.

Government of Ghana, 2011. *National Policy on Public-Private Partnership*. Accra: Ministry of Finance and Economic Planning.

Government of Ghana, 2010. *National Science, Technology and Innovation Policy*. Accra: Ministry of Environment, Science and Technology.

Government of Ghana, 2011. *The Industrial Sector Support Programme 2011-2015*. Accra: Ministry of Trade and Industry.

Gylfason, T., 2011. Oil-Spill Economics: How Ghana Can Succeed. *Vox,* [online] 27 March 2011. Available at: <www.voxeu.org>

Hargadon, A.B., 1998. Firms as Knowledge Brokers: Lessons in Pursuing Continuous Innovation. *California Management Review*, 40(3).

Harzing, A.W. 2006. Response Styles in Cross-National Survey Research. A 26-country Study. *The International Journal of Cross Cultural Management*, 6(2), pp.243-266.

Hilbert, M. López, P. and Vásquez C., 2010. Information Societies or "ICT Equipment Societies"? Measuring the Digital Information-Processing Capacity of a Society in Bits and Bytes*. The Information Society*, 26(3).

IFC (International Finance Corporation) and World Bank, 2012. *Doing Business 2012: Doing Business in a More Transparent World*. Economy Profile: Ghana. Washington DC: The World Bank Group.

*Innovation Nation White Paper* 2008. (Cm7345), London: BIS-UK.

Jones, C.I., 1997. On the Evolution of the World Income Distribution. Journal of Economic Perspectives, 11(3), pp.19-36.

Ju, J. Lin, J.L. and Wang, Y., 2011. Marshallian Externality, Industrial Upgrading and Industrial Policies. Policy Research Working Paper 5796. Washington, D.C.: The World Bank, Office of the Vice President, Development Economics.

Kaiser, H.F., 1974. An Index of Factorial Simplicity. *Psychometrika*, 39, pp.31-36.

Kapsali, M., 2010. Relating in Project Networks and Innovation Systems. In: DRUID (Danish Research Unit for Industrial Dynamics), *Summer Conference on Opening up Innovation Strategy, Organization and Technology*. London, UK 16-18 June 2010.

Karlan, D.S. et al., 2010. Being Surveyed Can Change Later Behavior and Related Parameter Estimates. *Proceedings of the National Academy of Science (PNAS*), 108(5), pp.1821–1826.

Kim, J.O. and Mueller, C.W., 1978. Factor Analysis: Statistical Methods and Practical Issues. *Quantitative Applications in Social Sciences Series*, 14. Thousand Oaks, CA: Sage Publications.

Kitchenham, B. and Pfieeger, S.L., 2002. Principles of Survey Research Part 4: Questionnaire Evaluation. *Software Engineering Notes*, 27(3), p.20-23.

Kline, P., 1999. *The Handbook of Psychological Testing*. 2nd ed. London: Routledge.

Koria, R. and Koszegi, S., 2011. National Systems of Innovation (NSI): Measurement and Implications for Science, Technology and Innovation Policy in Ghana. In: UNIDO (United Nations Industrial Development Organization), *Conference on Competitiveness and Diversification: Strategic Challenges in a Petroleum Rich Economy*. Accra, Ghana 14-15 March 2011.

Labovitz, S., 1967. Some Observations on Measurement and Statistics. *Social Forces*, 46(12), pp.151-160.

Labovitz, S., 1970. The Assignment of Numbers to Rank Order Categories. *American Sociological Review*, 35(2), pp.515-524.

Labovitz, S., 1971. In Defence of Assigning Numbers to Ranks. *American Sociological Review*, 36(4), pp.521-522 .

Legatum Institute, 2011. The Legatum Prosperity Index. Country: Ghana. Legatum Institute, [online] Available at: <http://www.prosperity.com/country.aspx?id=GH>

Lev, B. and Radhakrishnan, S., 2003. The Measurement of Firm-Specific Organization Capital. NBER Working Paper No. 9581, March.

Leydesdorff, L. and Meyer, M., 2006. Triple Helix Indicators of Knowledge-Based Innovation Systems: Introduction to the Special Issue. *Research Policy*, 35.

Leydesdorff, L. and Van den Besselaar, P. eds., 1994. *Evolutionary Economics and Chaos Theory: New Directions in Technology Studies*. London and New York: Pinter.

Leydesdorff, L., 2001. Knowledge-based Innovation Systems and the Model of a Triple Helix of University-Industry-Government relations. In: Universitá degli Studi di Salerno, *Conference on New Economic Windows: Paradigms for the New Millennium. Salerno*, Italia 13-15 Sep. 2001.

Leydesdorff, L., 2005. The Triple Helix Model and the Study of Knowledge-Based Innovation Systems. *International Journal of Contemporary Sociology*, 42(1).

Lundvall, B.Å. ed., 1992. National Systems of Innovation: Towards a Theory of Innovation and Interactive Learning. London: Printer.

Marshall, A., 1920. *Principles of Economics*. 8th ed. London: Macmillan and Company Ltd.

Metcalfe, S., 1995. The Economic Foundations of Technology Policy: Equilibrium and Evolutionary Perspectives. In: P. Stoneman, ed. 1995. *Handbook of the Economics of Innovation and Technological Change*. Oxford: Blackwell, p.38.

Moss, T. and Majerowitz, S., 2012. No Longer Poor: Ghana's New Income Status and Implications of Graduation from IDA. Working Paper 300. Washington, D.C.: Centre for Global Development (CGD).

Munk, K.B. and Vintergaard, C., 2004. Venture Capitalists in Systems of Innovation. MPP Working Paper 1/2004, Department of Management, Politics and Philosophy. Copenhagen: Copenhagen Business School.

Nelson, R.R. and Rosenberg, N., 1993. Technical Innovation and National Systems. In: R.R. Nelson, ed. 1993. *National Systems of Innovation: a Comparative Study*. Oxford: Oxford University Press, p.4.

Nelson, R.R. and Winter, S., 1982. *An Evolutionary Theory of Economic Change*. London: The Belknap Press of Harvard University.

Niosi, J., Saviotti, P.P., Bellon, B., Crow, M., 1993. National systems of innovations: in search of a workable concept. Technology in Society 15, 207–227.

North, D.C., 1991. *Institutions, Institutional Change and Economic Performance. Political Economy of Institutions and Decisions*. Cambridge: Cambridge University Press.

Obeng, T.K., 2004. Practical Application of ICT to Enhance University Education in Ghana. GhanaWeb, [online] 30 April 2004. Available at: <http://www.ghanaweb.com/GhanaHomePage/features/artikel.php?ID=56932> [Accessed on 24 April 2012].

OECD (Organization for Economic Cooperation and Development) and EUROSTAT (Statistical Office of the European Communities), 2005. *The Oslo Manual. Guidelines for Collecting and Interpreting Innovation Data*. 3rd ed. Paris: OECD Publishing.

OECD (Organization for Economic Cooperation and Development), 1997. *National Systems of Innovation: Background Report*. DSTI/STP/TIP, (97)2. Paris: OECD Publishing, p.7.

OECD (Organization for Economic Cooperation and Development), 1999. Managing National Innovation Systems. Paris: OECD Publishing.

OECD (Organization for Economic Cooperation and Development), 2002. *Frascati Manual. Proposed Standard Practice for Surveys on Research and Experimental Development*. Paris: OECD Publishing.

OECD (Organization for Economic Cooperation and Development), 2005. *Innovation Policy and Performance: a Cross-Country Comparison*. Paris: OECD Publishing.

OECD (Organization for Economic Cooperation and Development), 2012. *Science, Technology and Industry Outlook*. Paris: OECD Publishing.

Patel, P. and Pavitt, K., 1994. National Innovation Systems: Why They Are Very Important, and How They Might Be Measured and Compared, *Economics of Innovation and New Technology*, p. 5.

*Patent Act 2003* (Act 657). Accra: Government of Ghana.
Perez, C., 1983. Structural Change and Assimilation of New Technologies in the Economic and Social Systems. *Futures*, 15(5), pp.357–75.

Porter, M.E., 1990. *The Competitive Advantage of Nations*. New York: Free Press.

Quah, D.T., 1996. Twin Peaks: Growth and Convergence in Models of Distribution Dynamics. Discussion Paper 280, Centre for Economic Performance. London: London School of Economics (LSE).

Quah D.T., 1997. Empirics for Growth and Distribution: Stratification, Polarization and Convergence Clubs. Discussion Paper 324, Centre for Economic Performance. London: London School of Economics (LSE).

Rummel, R.J., 1970. *Applied Factor Analysis*. Evanston: Northwestern University Press.

Saxenian, A., 2005. From Brain Drain to Brain Circulation: Transnational Communities and Regional Upgrading in India and China. *Studies in Comparative International Development,* 40(2), pp.35-61.

Schoser, C., 1999. The Institutions Defining National Systems of Innovation: a New Taxonomy to Analyse the Impact of Globalization. In: EAEPE (European Association of Evolutionary Political Economy), *Conference on Inequality and Integration: Challenges for Institutional Economics.* Prague, Czech Republic 4-7 Nov. 1999.

Schwab, K., 2010. The Global Competitiveness Report 2010-2011. Geneva: World Economic Forum.

Shinn, T., 2002. The Triple Helix and New Production of Knowledge: Prepackaged Thinking on Science and Technology. *Social Studies of Science*, 32(4), pp.599-614.

STEPRI (Science and Technology Policy Research Institute), 2010. *The Ghana Innovation Survey Report 2009*. Accra: CSIR-STEPRI.

The Economist, 2000. The Hopeless Continent. *The Economist,* 13 May 2000.

The Economist, 2011. Africa Rising. *The Economist*, 3 Dec. 2011.

The World Bank, 2012. *World Development Indicators*. Washington D.C: The World Bank.

UNCTAD (United Nations Conference on Trade and Development), 2011. *Science, Technology and Innovation Policy Review*. Geneva: United Nations.

UNIDO (United Nations Industrial Development Organization), 2005. Dynamics of National Systems of Innovation in Developing Countries and Transition Economies. Technology Paper Series 1/2005, Industrial Promotion and Technology Branch. Vienna: United Nations.

UNIDO (United Nations Industrial Development Organization), 2011. *Conference on Competitiveness and Diversification: Strategic Challenges in a Petroleum Rich Economy*. Accra, Ghana 14-15 March 2011, p.79. Vienna: United Nations.

Wagner, C.S. Brahmakulam, I. Jackson, B. Wong A. and Yoda, T., 2001. *Science and Technology Collaboration: Building Capacity in Developing Countries?* Santa Monica: RAND Publications, Science and Technology, p.6.

Weitzman, H., 2012. Survey Shows No Let-Up in 'Skills Gap'. *Financial Times*, 29 May 2012.

Williamson, O.E., 1969. Allocative Efficiency and the Limits of Antitrust. *American Economic Review,* 59(2), pp.105–118.

Williamson, O.E., 1971. The Vertical Integration of Production: Market Failure Considerations. *American Economic Review*, 61(2), pp.112–123.

Williamson, O.E., 1973. Markets and Hierarchies: Some Elementary Considerations. *American Economic Review*, 63(2), pp.316–325.

World Bank, 2011. *Africa's Future and the World Bank's Support to It*. Washington: The World Bank.

WTO (World Trade Organization), 1994. *Agreement on Subsidies and Countervailing Measures.* Identification of Non-Actionable Subsidies, s. IV(8).

Zook, M.A., 2003. The Knowledge Brokers: Venture Capitalists, Tacit Knowledge and Regional Development. In: DRUID (Danish Research Unit on Industrial Dynamics), *Summer Conference on Creating and Sharing, Sharing and Transferring Knowledge. The Role of Geography, Institutions and Organizations*. Copenhagen, Denmark 12-14 June 2003.

# Annex I - Importance of Actor and Strength of intra-Linkages

**Importance of Actor: GOV**

| | ALL | | GOV | | MHTI | | KBI | | ARB | |
|---|---|---|---|---|---|---|---|---|---|---|
| Linkage | VI-VS | VI-VW | VI-VS | VI-VW | VI-VS | VI-VW | VI-VS | VI-VW | VI-VS | VI-VW |
| GOV-GOV | 61.2 | 29.4 | | | 44.9 | 33.3 | | | | |
| GOV-ISTC | 35.1 | 55.4 | 48.7 | 46.3 | | | | | 66.7 | 33.4 |

**Importance of Actor: ISTC**

| | ALL | | GOV | | MHTI | | KBI | | ARB | |
|---|---|---|---|---|---|---|---|---|---|---|
| Linkage | VI-VS | VI-VW | VI-VS | VI-VW | VI-VS | VI-VW | VI-VS | VI-VW | VI-VS | VI-VW |
| GOV-ISTC | 33.8 | 52.9 | | | | | 31.1 | 56.6 | | |

**Importance of Actor: HE**

| | ALL | | GOV | | MHTI | | KBI | | ARB | |
|---|---|---|---|---|---|---|---|---|---|---|
| Linkage | VI-VS | VI-VW | VI-VS | VI-VW | VI-VS | VI-VW | VI-VS | VI-VW | VI-VS | VI-VW |
| HE-HE | 63.7 | 25.5 | | | 48.2 | 33.3 | | | | |
| HE-RI | 54.6 | 34.6 | | | | | 59.6 | 31.9 | | |
| RI-HE | 54.3 | 35.1 | | | | | 61.3 | 30.4 | | |

**Importance of Actor: RI**

| | ALL | | GOV | | MHTI | | KBI | | ARB | |
|---|---|---|---|---|---|---|---|---|---|---|
| Linkage | VI-VS | VI-VW | VI-VS | VI-VW | VI-VS | VI-VW | VI-VS | VI-VW | VI-VS | VI-VW |
| RI-RI | 62.0 | 27.7 | | | | | 67.5 | 24.8 | | |
| RI-HE | 54.2 | 35.5 | | | | | 61.3 | 31.2 | | |
| HE-RI | 54.7 | 35.0 | | | | | 59.8 | 32.6 | | |

**Importance of Actor: BE**

| | ALL | | GOV | | MHTI | | KBI | | ARB | |
|---|---|---|---|---|---|---|---|---|---|---|
| Linkage | VI-VS | VI-VW | VI-VS | VI-VW | VI-VS | VI-VW | VI-VS | VI-VW | VI-VS | VI-VW |
| BE-BE | | | | | 51.7 | 31.6 | | | | |

**Importance of Actor: FI**

| | ALL | | GOV | | MHTI | | KBI | | ARB | |
|---|---|---|---|---|---|---|---|---|---|---|
| Linkage | VI-VS | VI-VW | VI-VS | VI-VW | VI-VS | VI-VW | VI-VS | VI-VW | VI-VS | VI-VW |
| ARB-FI | 48.7 | 36.4 | | | | | 45.8 | 40.4 | | |

**Importance of Actor: ARB**

| | ALL | | GOV | | MHTI | | KBI | | ARB | |
|---|---|---|---|---|---|---|---|---|---|---|
| Linkage | VI-VS | VI-VW | VI-VS | VI-VW | VI-VS | VI-VW | VI-VS | VI-VW | VI-VS | VI-VW |
| ARB-FI | | | | | 44.9 | 26.7 | | | | |

# Annex II - List of Government Ministries

## Regional Ministries

Regional Ministry - Ashanti Region
Regional Ministry - Brong Ahafo Region
Regional Ministry - Central Region
Regional Ministry - Eastern Region
Regional Ministry - Greater Accra Region
Regional Ministry - Northern Region
Regional Ministry - Upper East Region
Regional Ministry - Upper West Region
Regional Ministry - Volta Region
Regional Ministry - Western Region

## Ministries

Ministry of Chieftaincy and Culture
Ministry of Communication
Ministry of Defence
Ministry of Education
Ministry of Employment and Social Welfare
Ministry of Energy
Ministry of Environment, Science and Technology
Ministry of Finance and Economic Planning
Ministry of Food and Agriculture
Ministry of foreign Affairs and Regional Integration
Ministry of Information
Ministry of Interior
Ministry of Lands and Natural Resources
Ministry of Local Government and Rural Development
Ministry of Roads and Highways
Ministry of Trade and Industry
Ministry of Transportation
Ministry of Water Resources, Works and Housing
Ministry of Youth and Sports
Office of the President
Policy Planning Monitoring & Evaluation Division

## Parliamentary Select Committees

Committee on Communications
Committee on Constitutional Legal & Parliamentary Aff.
Committee on Defence and Interior
Committee on Education
Committee on Employment, Social Welfare & SOEs
Committee on Environment, Science and Technology
Committee on Food, Agriculture and Cocoa Affairs
Committee on Foreign Affairs
Committee on Gender and Children's Affairs
Committee on Health
Committee on Information
Committee on Lands and Forestry
Committee on Local Government & Rural Development
Committee on Mines and Energy
Committee on Roads and Transport
Committee on Tourism
Committee on Trade, Industry and Tourism
Committee on Transportation
Committee on Water Resources, Works and Housing
Committee on Youth, Sports and Culture
Judiciary Committee
Public Accounts Committee

## Parliamentary Standing Committees

Appointments Committee
Business Committee
Committee on Finance
Committee on Gender and Children
Committee on Government Assurance
Committee on House
Committee on Judiciary
Committee on Members Holding Offices of Profit
Committee on Poverty Reduction Strategy
Committee on Privileges
Committee on Selection
Committee on Special Budget
Committee on Subsidiary Legislation
Committee on Subsidiary Legislation
Public Accounts Committee
Standing Orders Committee

## Ad Hoc Committee

Committee on Poverty Reduction Strategy

## Departments and Agencies

Bulk Oil Storage and Transportation Company Ltd
Electricity Company of Ghana Ltd
Forest Services Division
Forestry Commission
Ghana Free Zones Board
Ghana Highway Authority
Ghana National Petroleum Corporation
Ghana Oil Company Ltd
Ghana Statistical Service
Land Registration Division (Lands Commission)
Lands Commission, Survey and Mapping Division
Minerals Commission
National Board for Small Scale Industries
National Development Planning Commission
National Petroleum Authority
National Road Safety Commission
Tema Oil Refinery
Timber Industry Development Department
Volta River Authority
Wildlife Division

# Annex III - List of Knowledge-Based Institutions

Accra Institute of Technology
Advanced Business College
Ashesi University College
Bolgatanga Polytechnic
Cape Coast Polytechnic
Catholic Institute of Business and Technology
Catholic University College of Ghana
Central University College
Centre for Policy Analysis
Centre for Scientific Research into Plant Medicine
Christian Service University College
Cocoa Research Institute of Ghana
Council for Scientific and Industrial Research
Evangelical Presbyterian University College
Ghana Institute of Management and Public Administration (GIMPA)
Institute of Business Management and Journalism
Institute of Statistical, Social and Economic Research (ISSER)
Kings University College
Koforidua Polytechnic
Kwame Nkrumah University of Science and Technology
Methodist University College
NIIT-Tema
Noguchi Memorial Institute for Medical Research
Pentecost University College
Presbyterian University College
Radford University College
Regent University College of Science and Technology
Regional Maritime University
Sunyani Polytechnic
Tamale Polytechnic
University for Development Studies
University of Education Winneba
University of Education, Kumasi Campus
University of Ghana
University of Ghana Medical School
Valley View University
Wa Polytechnic
Wisconsin International University College
Zenith University

# Annex IV - Enlarged Figures

***Figure 9.3*** *– Government Inter-, Intra-Linkages*

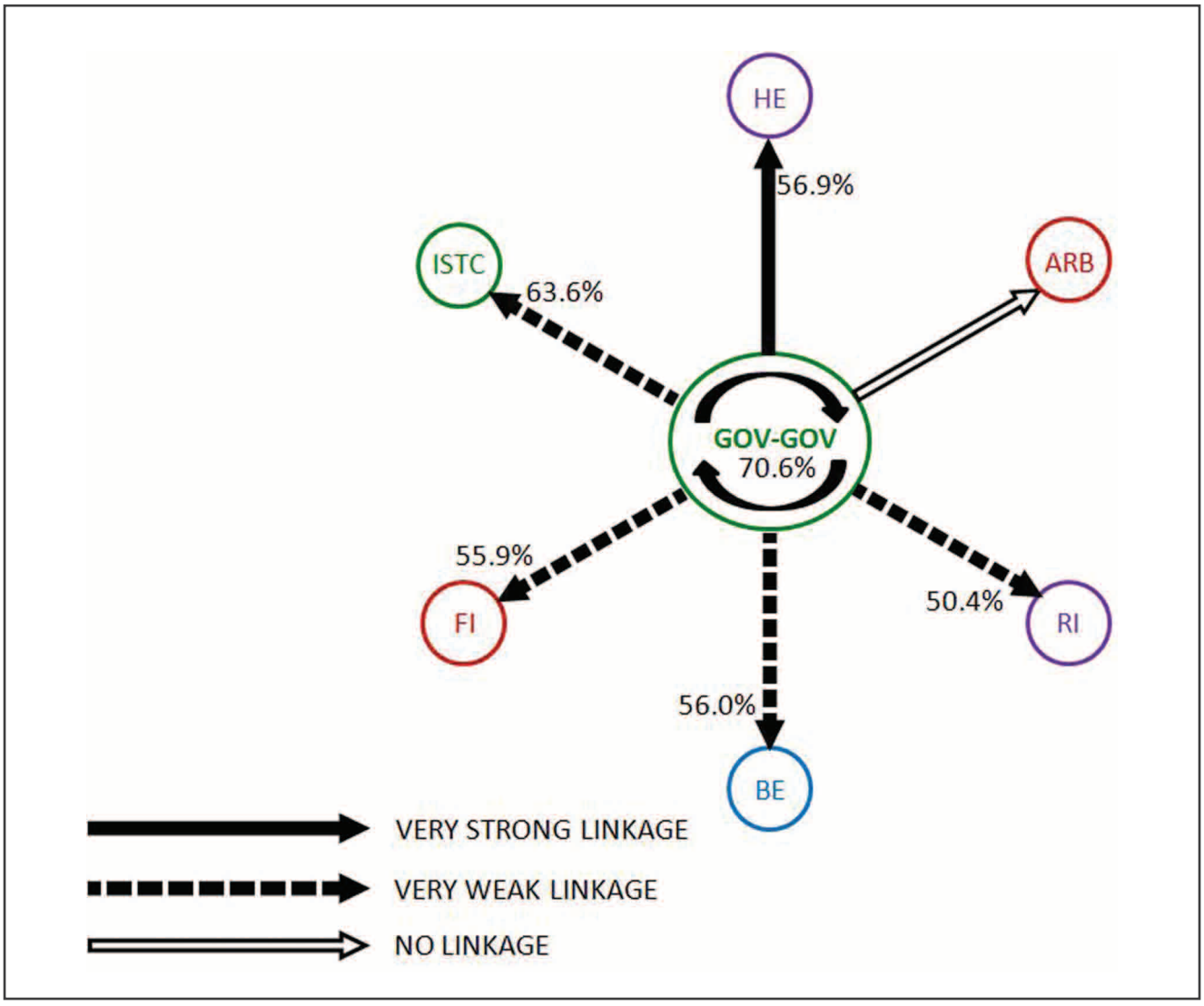


***Figure 9.4*** *– Government Assessment of Other Actors' Inter-Linkages*

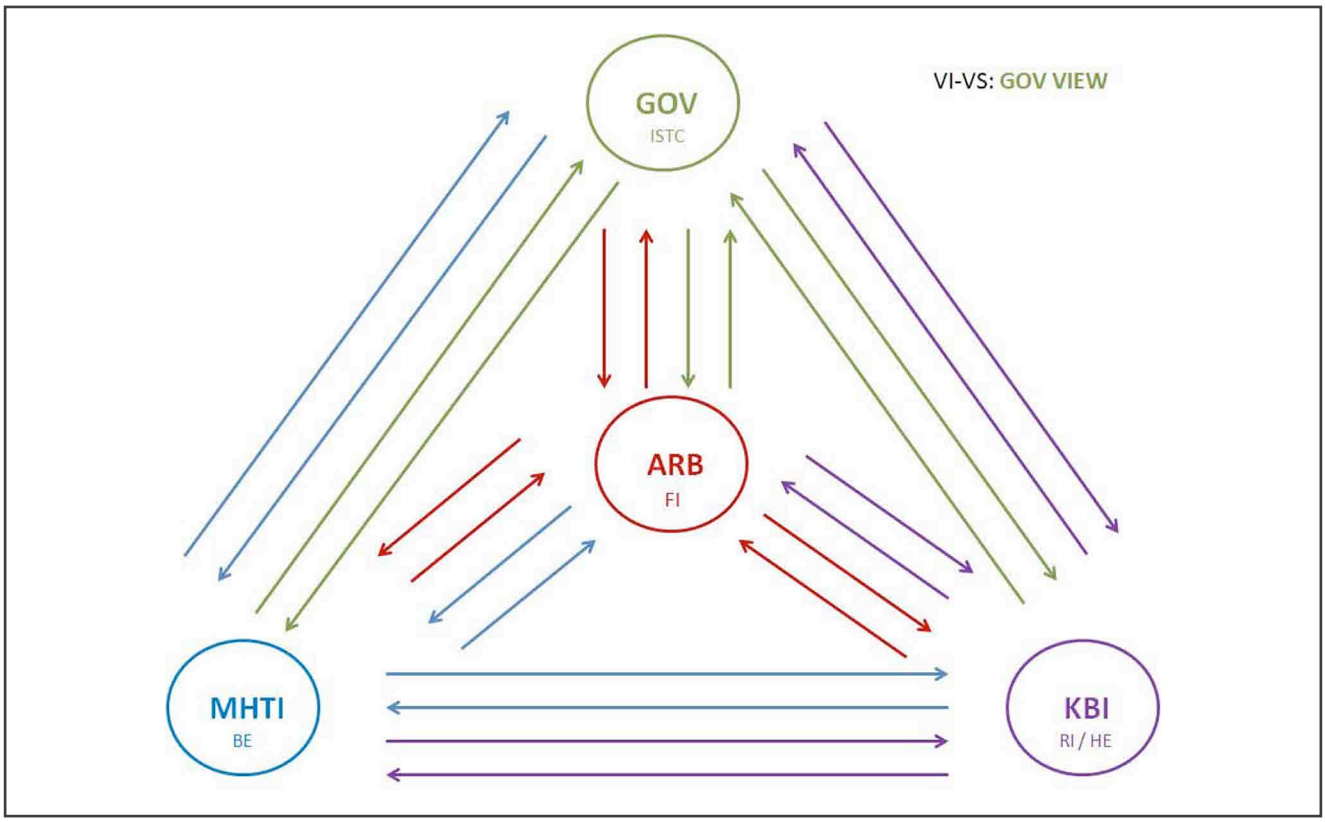



***Figure 9.5*** *– Business Enterprise Inter-, Intra-Linkages*

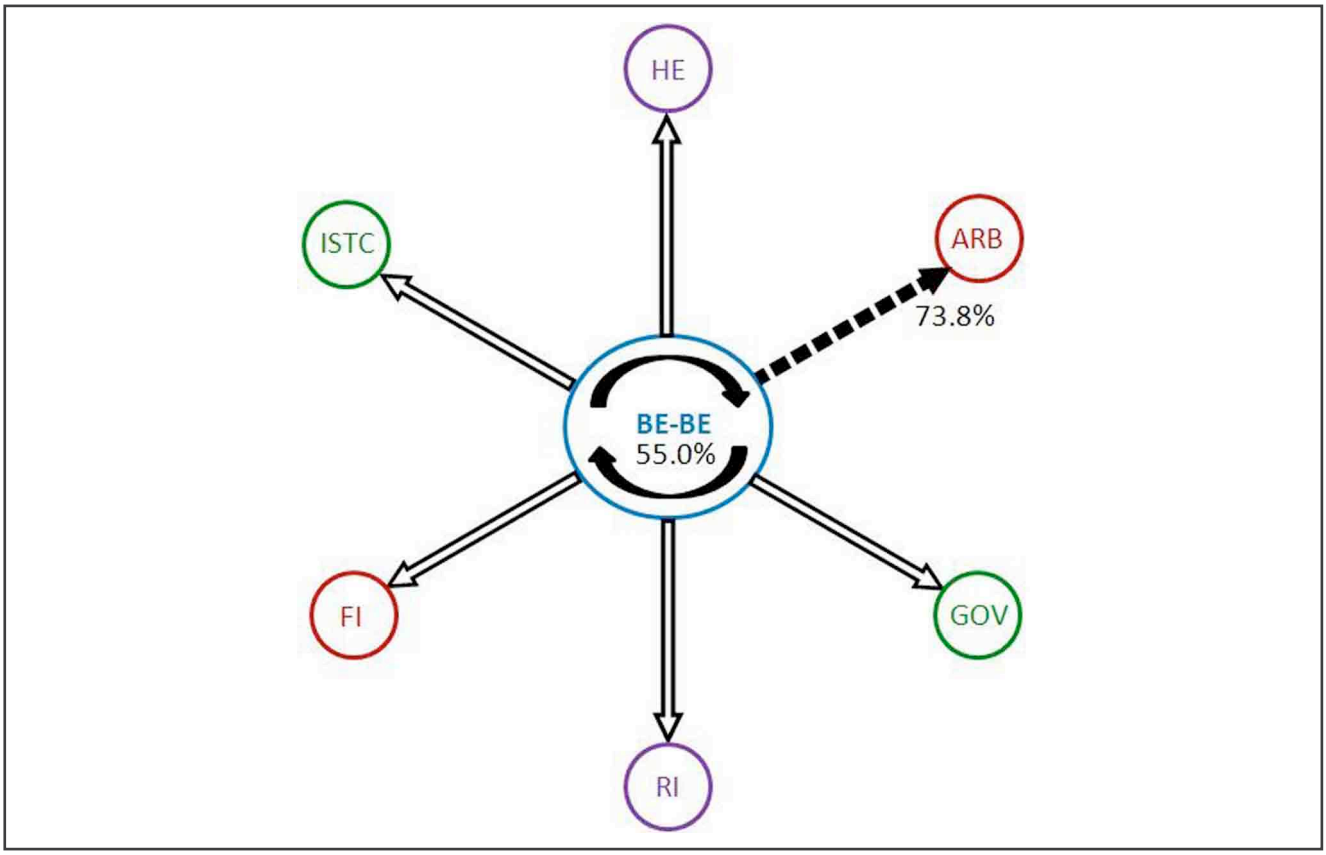


***Figure 9.6*** *– Medium and High-Tech Industry Assessment of Other Actors' Inter-Linkages*

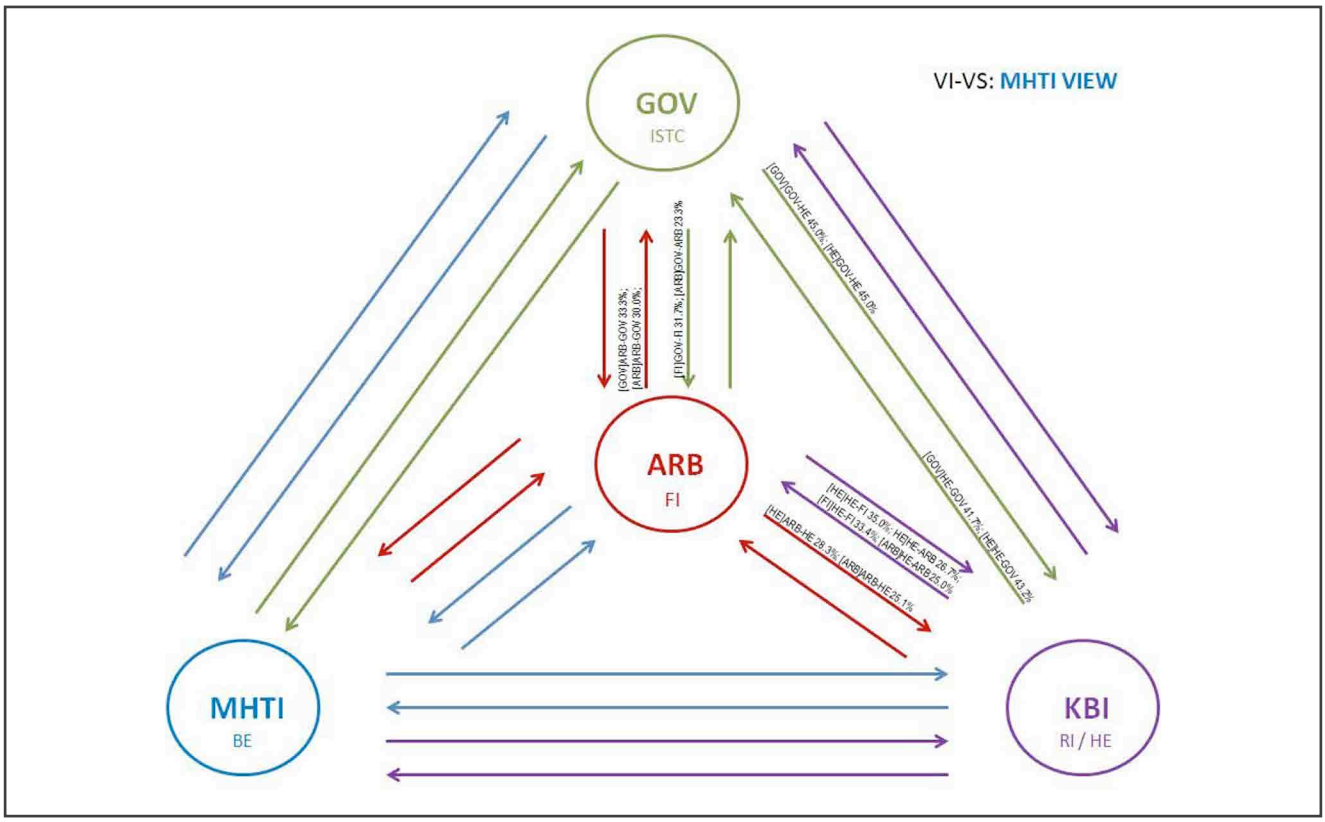



***Figure 9.7*** *– Higher Education Inter- Intra-Linkages*

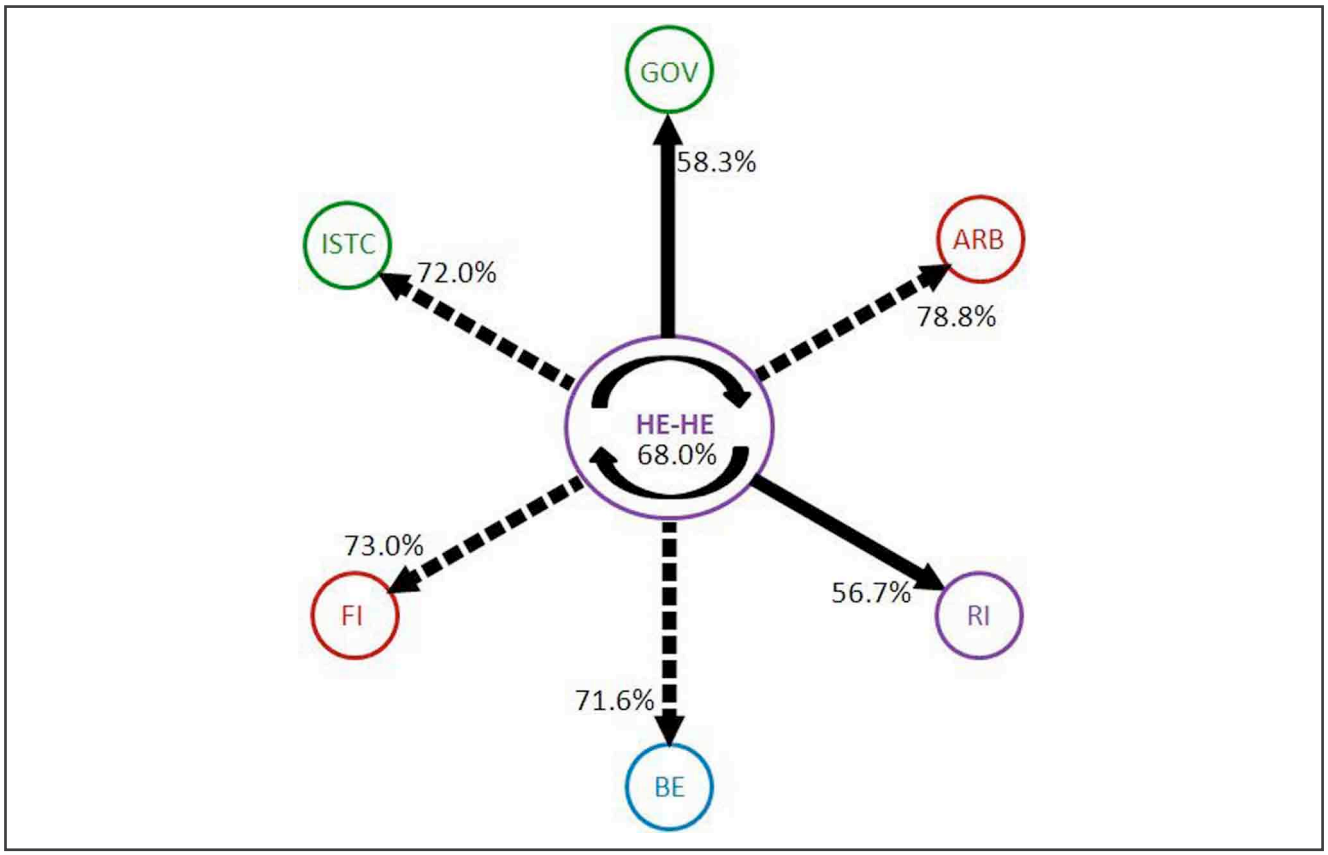


***Figure 9.8*** *– Research Institute Inter- Intra-Linkages*

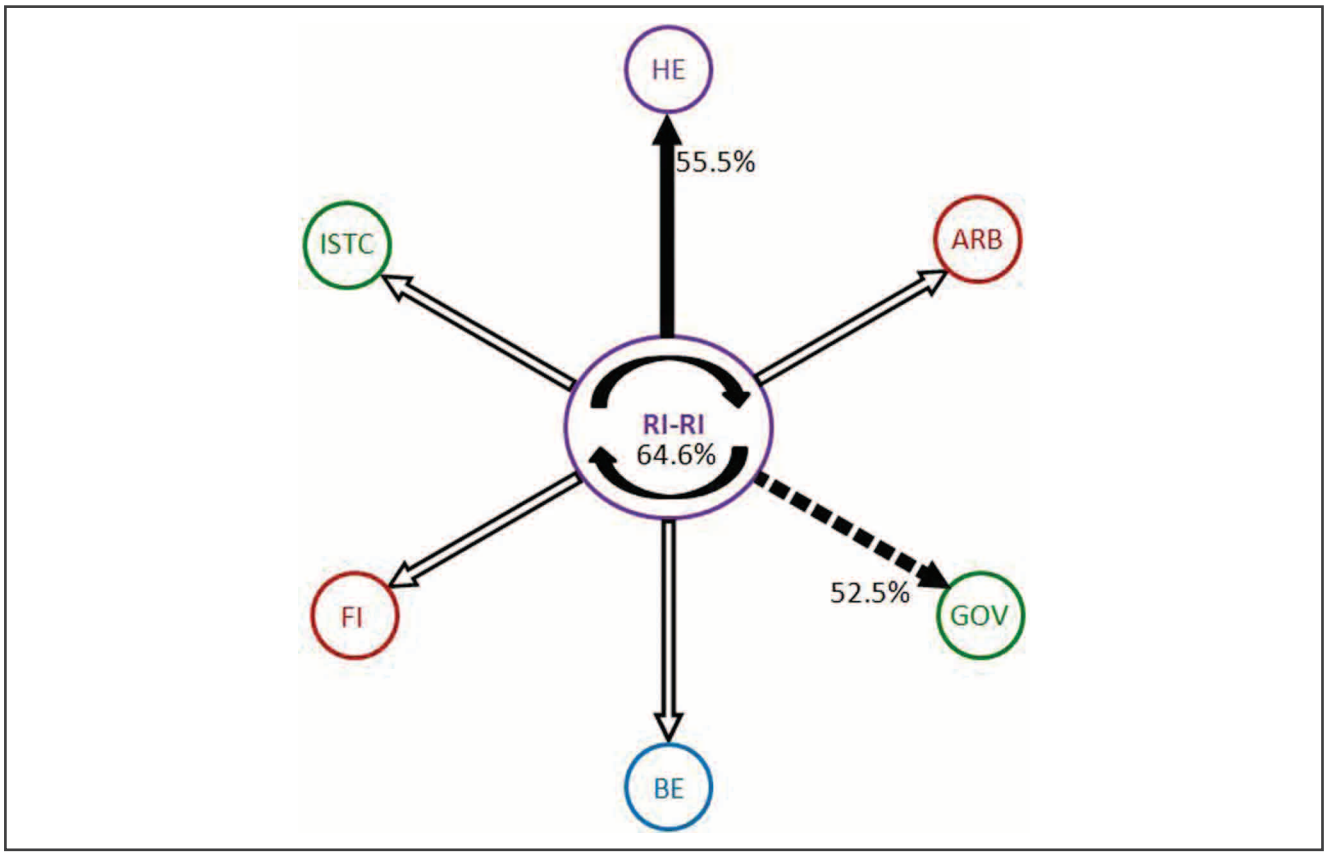



***Figure 9.9*** *– Knowledge-Based Institution Assessment of Other Actors' Inter-Linkages*

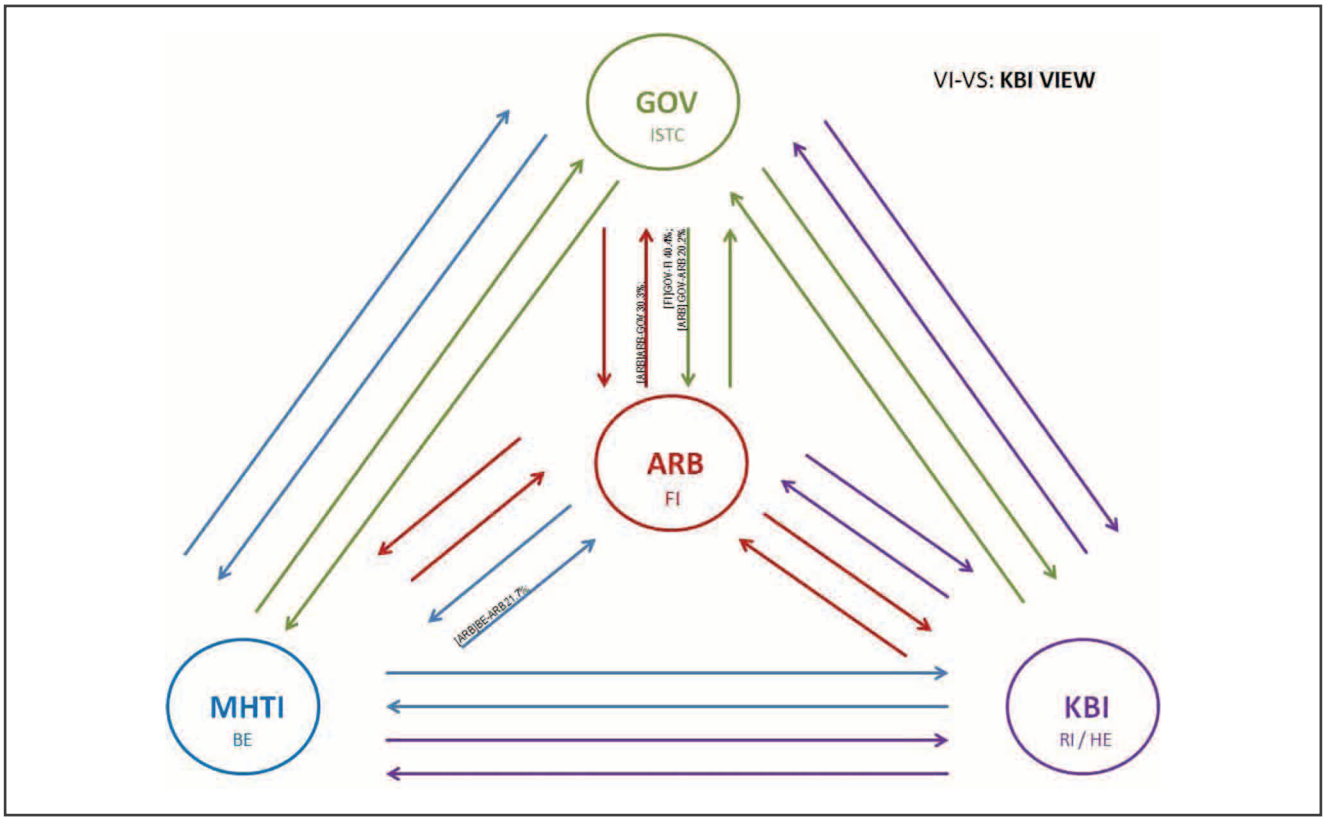


***Figure 9.10*** *– Arbitrageur Inter- Intra-Linkages*

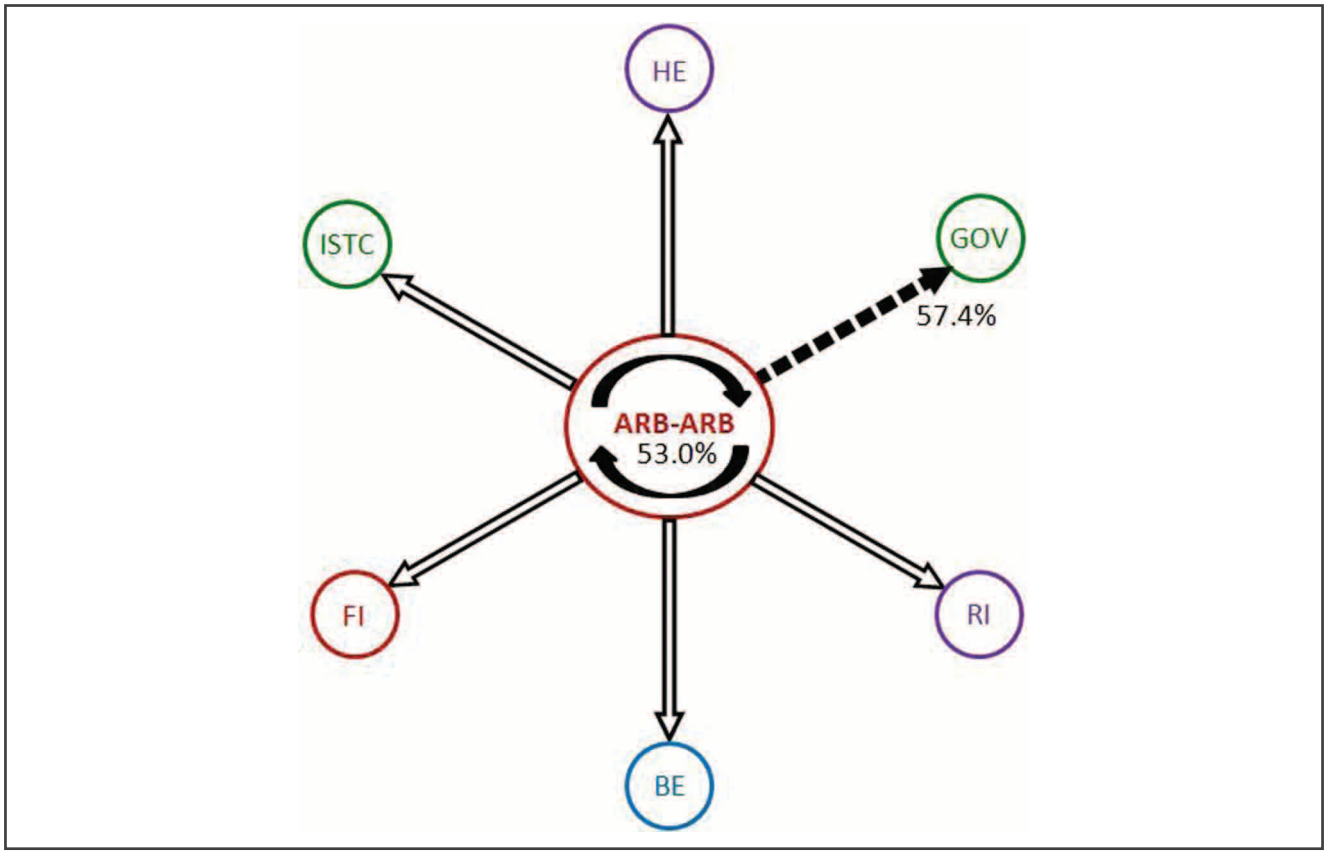



***Figure 9.11*** *– Arbitrageur Assessment of Other Actors' Inter-Linkages*

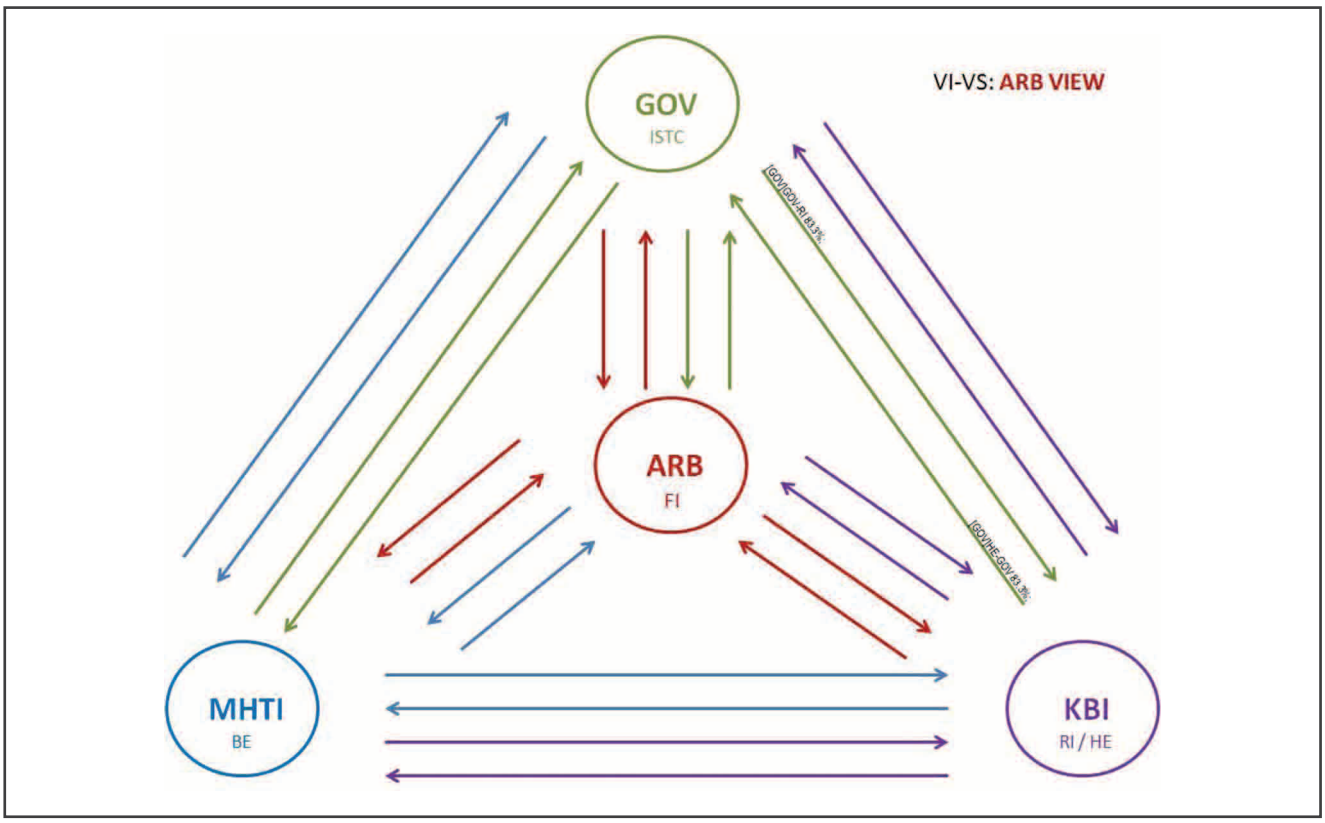


***Figure 9.12*** *– Actor-Centric Assessment of Inter Linkages (Very Important- Very Strong)*

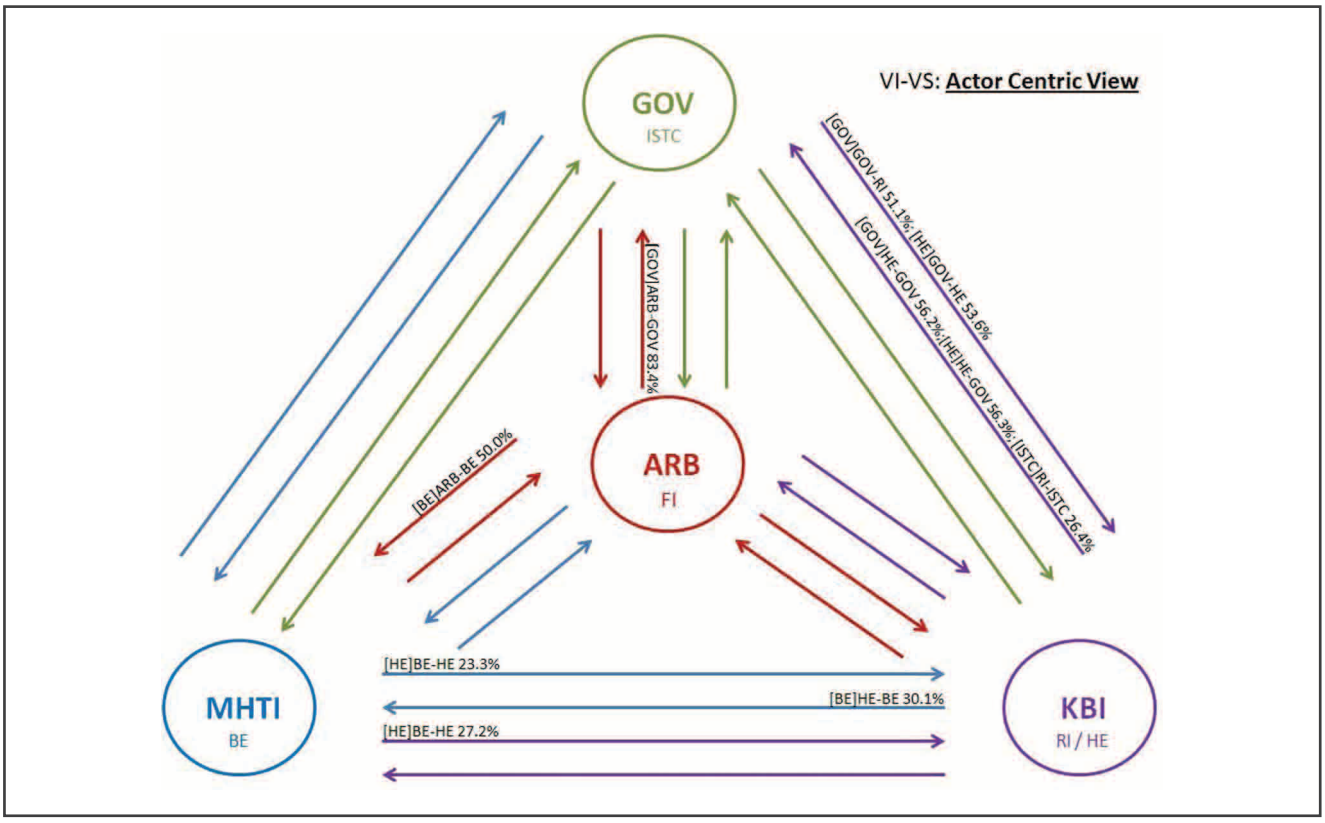



***Figure 9.13*** *– Actor Centric Assessment of Inter Linkages (Very Important- Very Weak)*

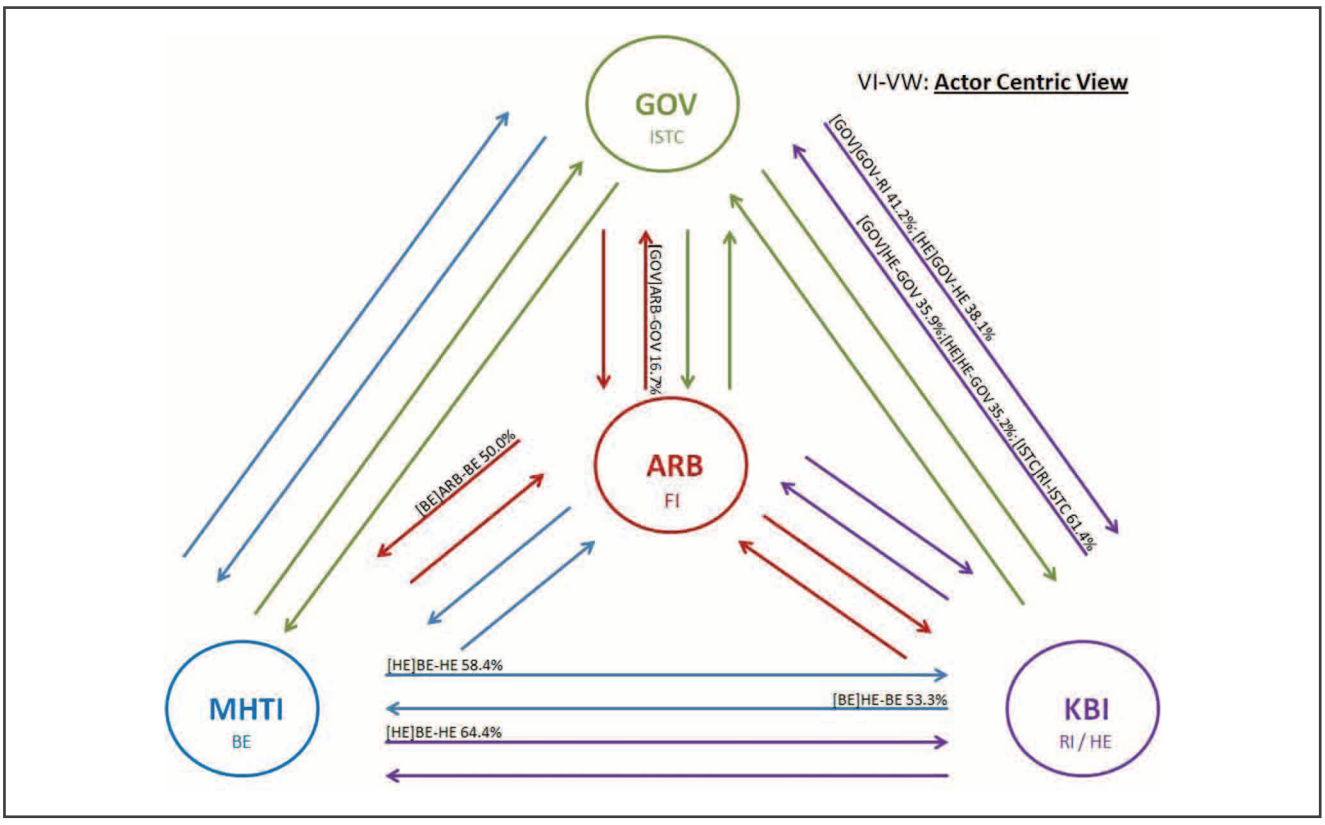


***Figure 9.14*** *– Government View of Linkages and Level of Innovativeness – VS-VHI*

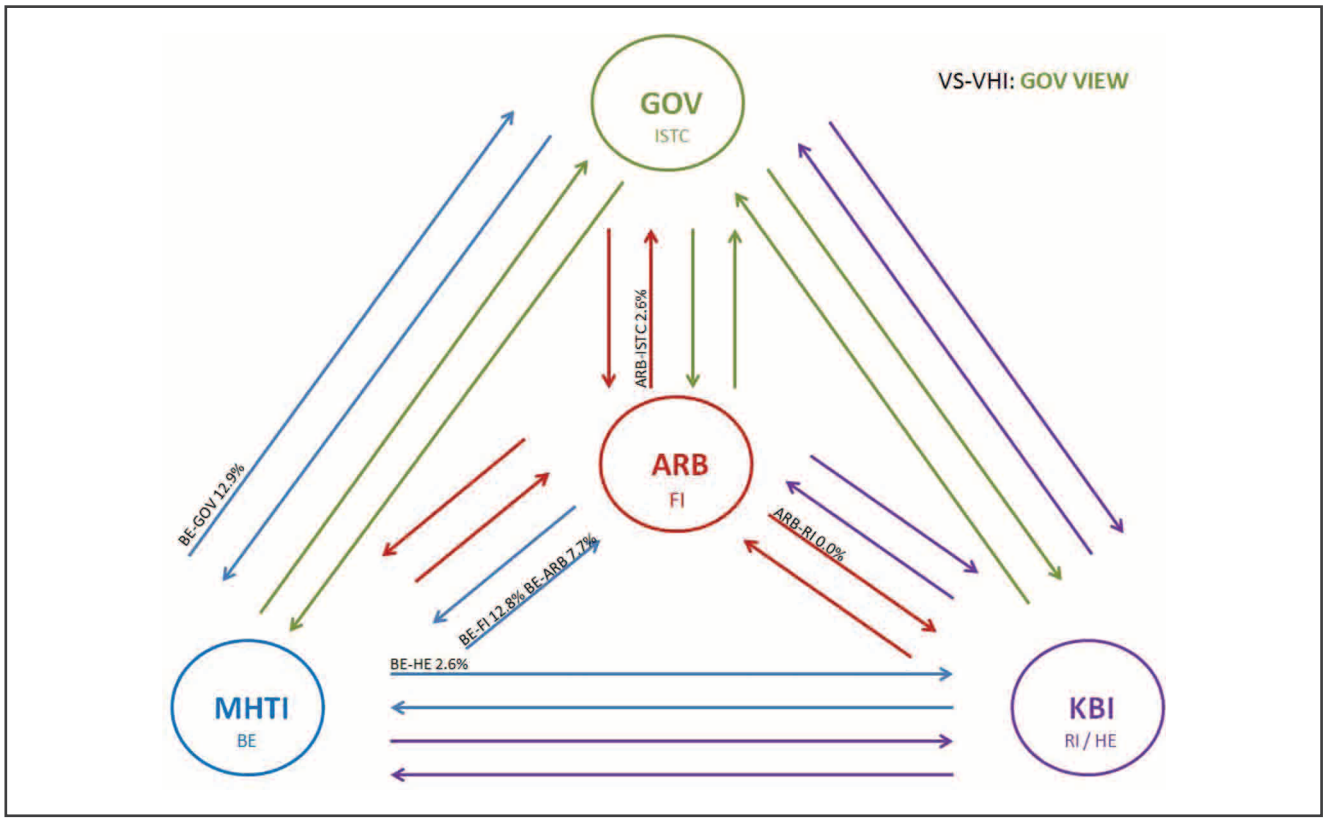



***Figure 9.15*** *– Government View of Linkages and Level of Innovativeness – VS-VLI*

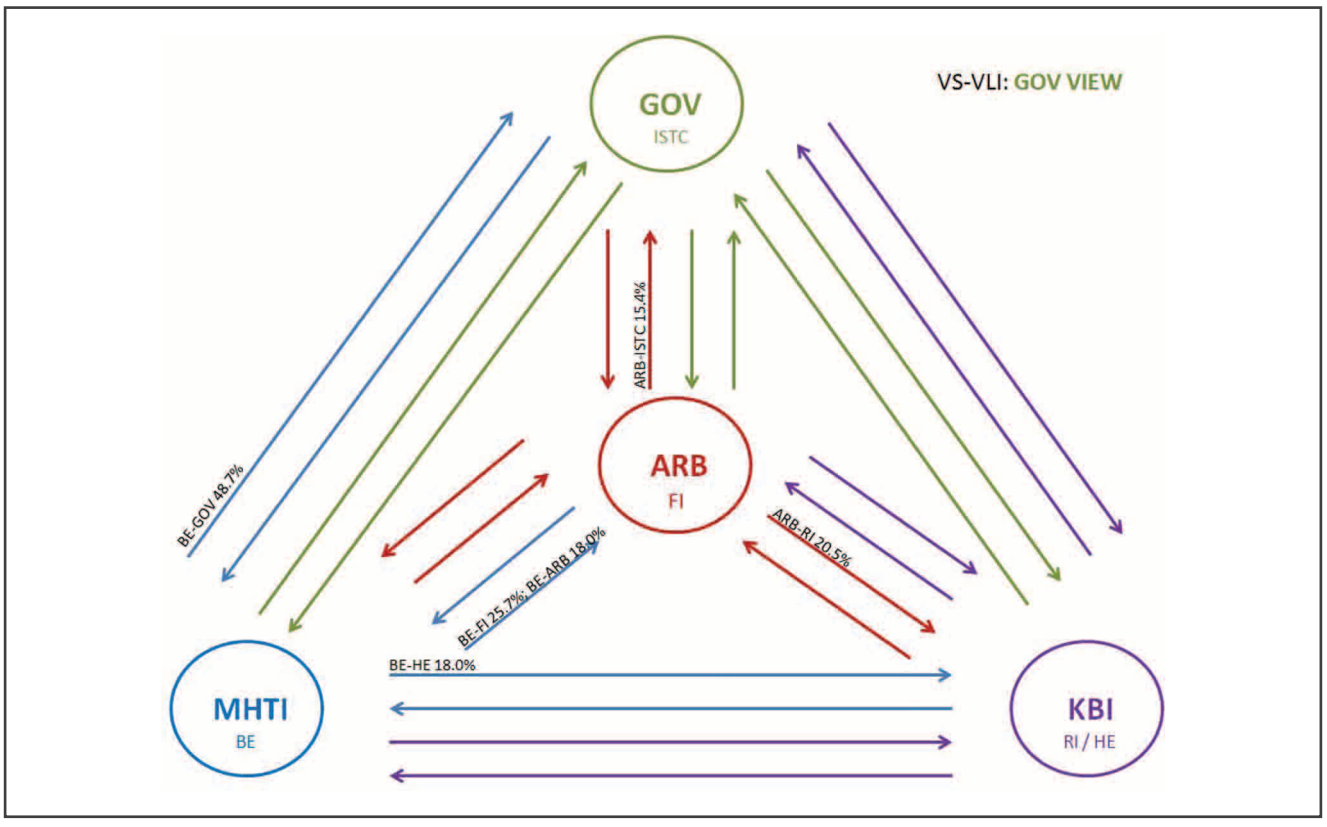


***Figure 9.16*** *– Medium and High-Tech Industry View of Linkages and Level of Innovativeness – VS-VHI)*

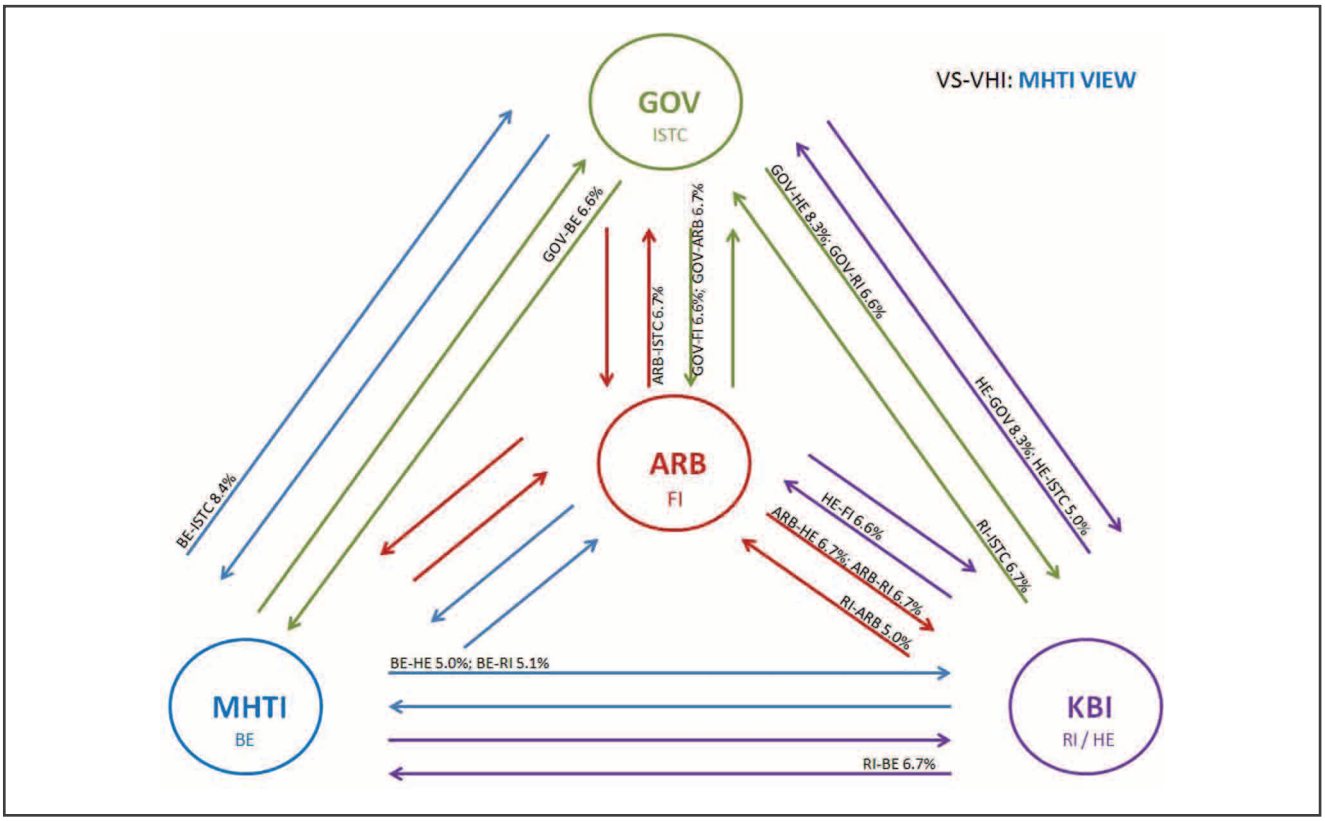



***Figure 9.17*** *– Medium and High-Tech Industry View of Linkages and Level of Innovativeness – VS-VLI)*

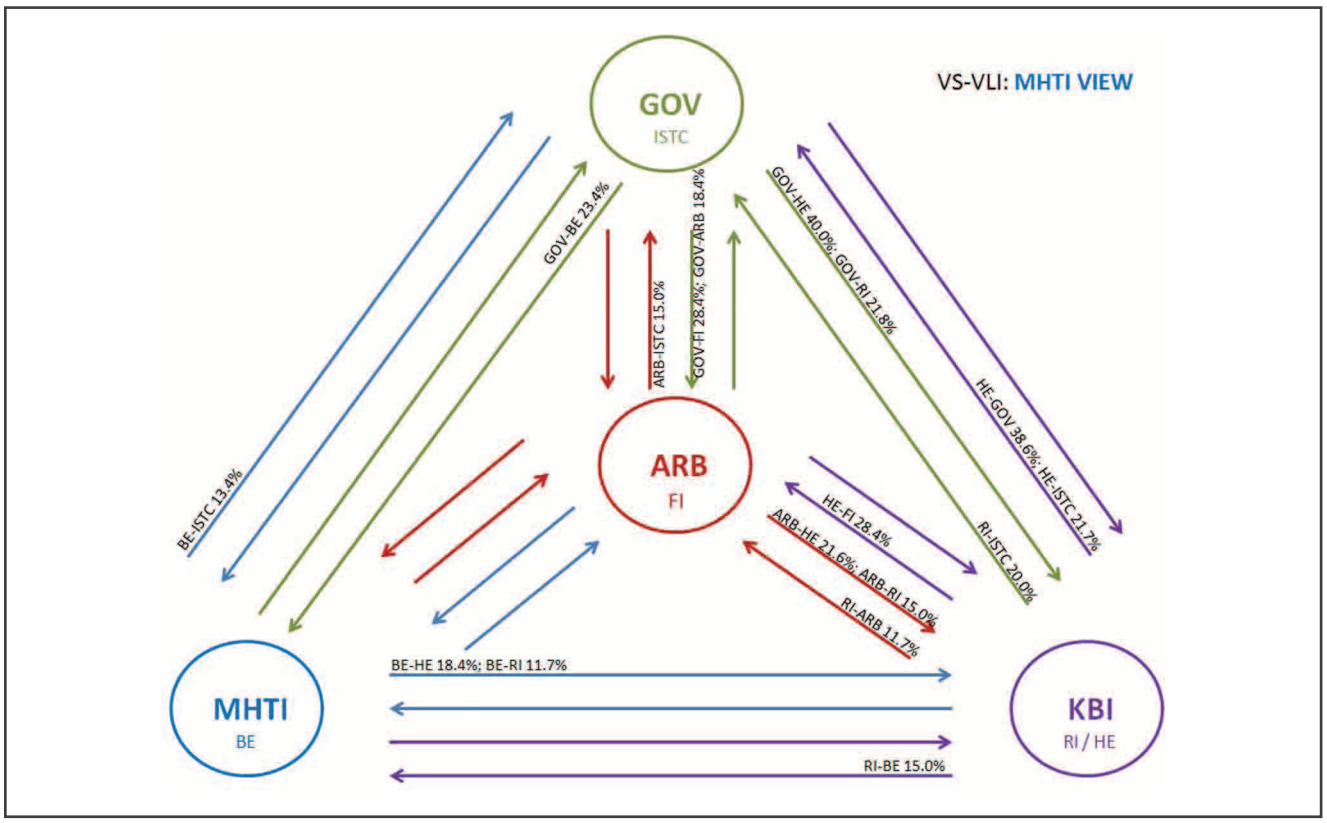


***Figure 9.18*** *– Knowledge-Based Institution View of Linkages and Level of Innovativeness – VS-VHI)*

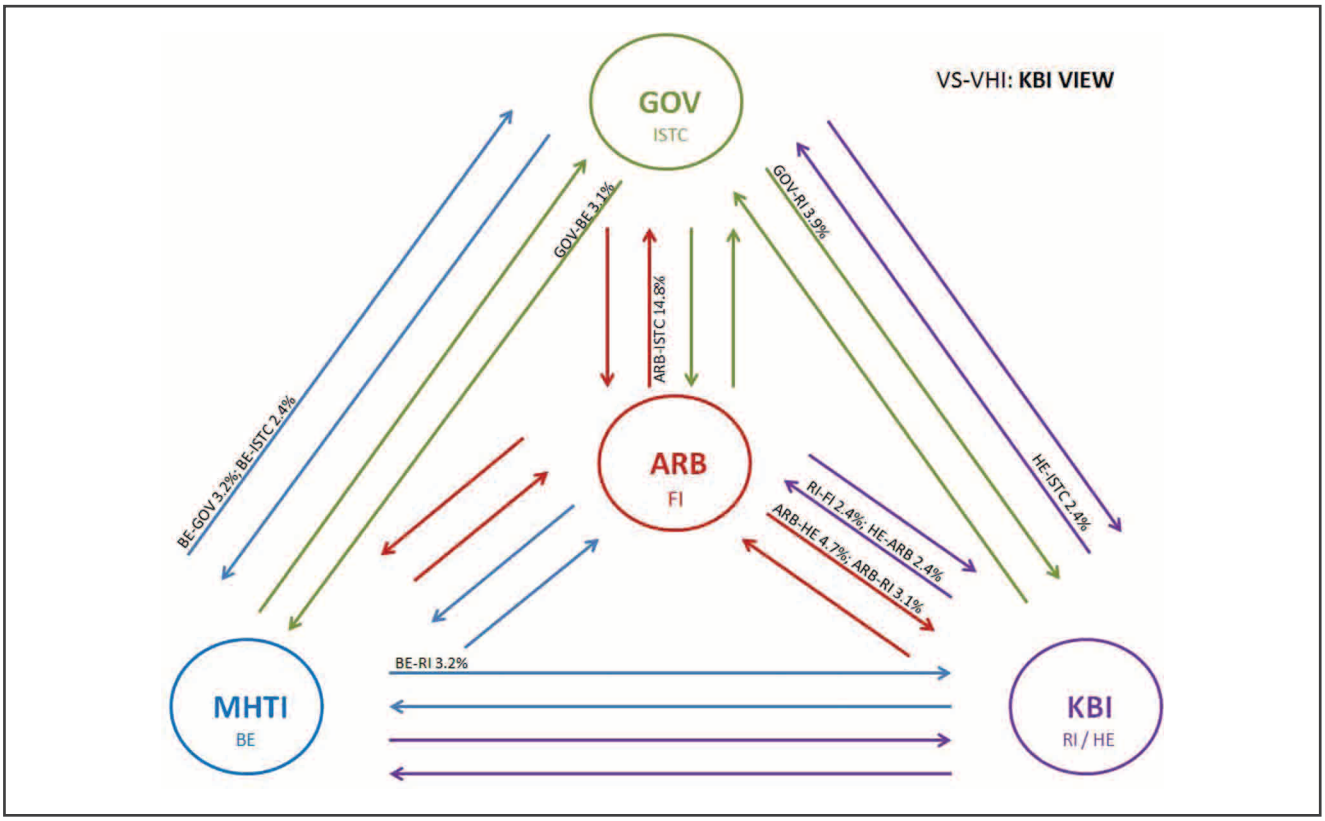



***Figure 9.19*** *– Knowledge-Based Institution View of Linkages and Level of Innovativeness – VS-VLI)*

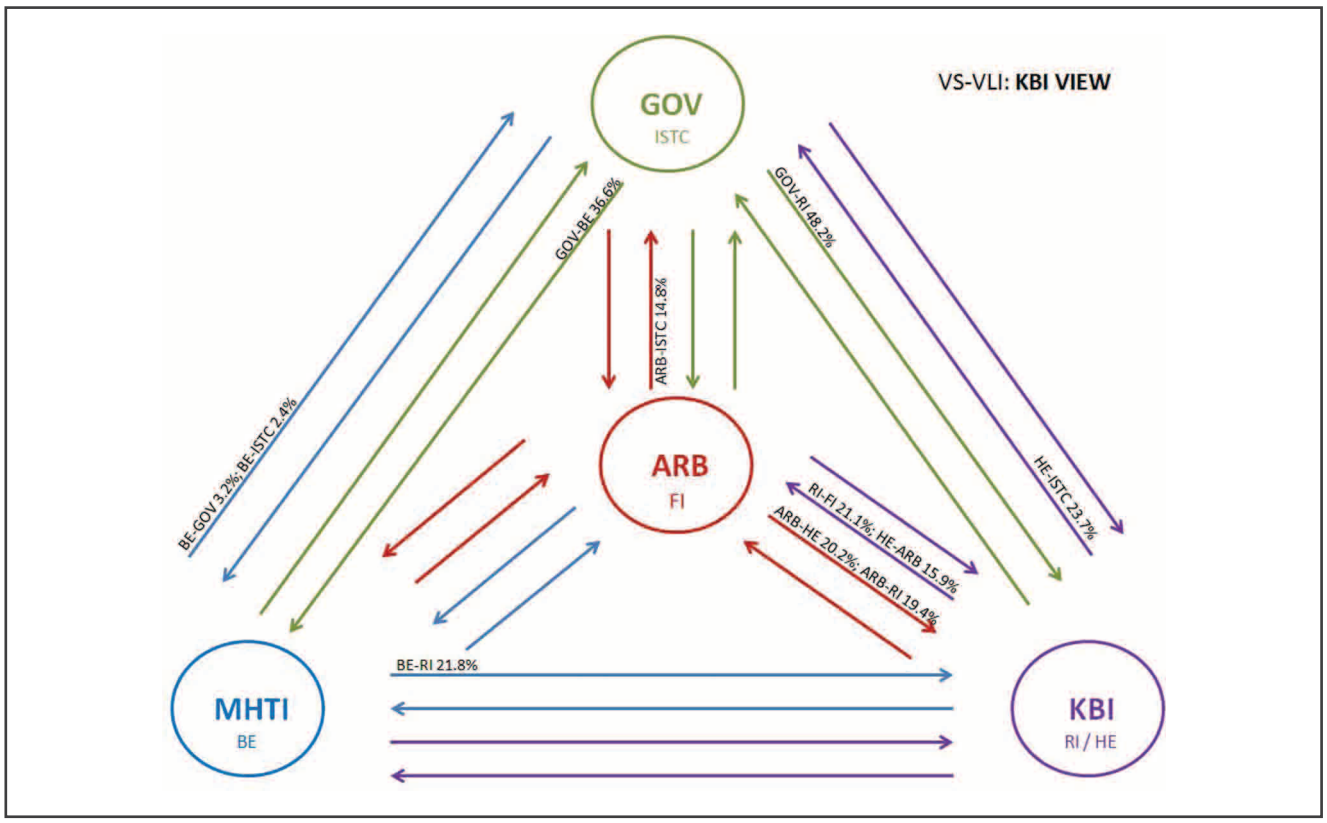
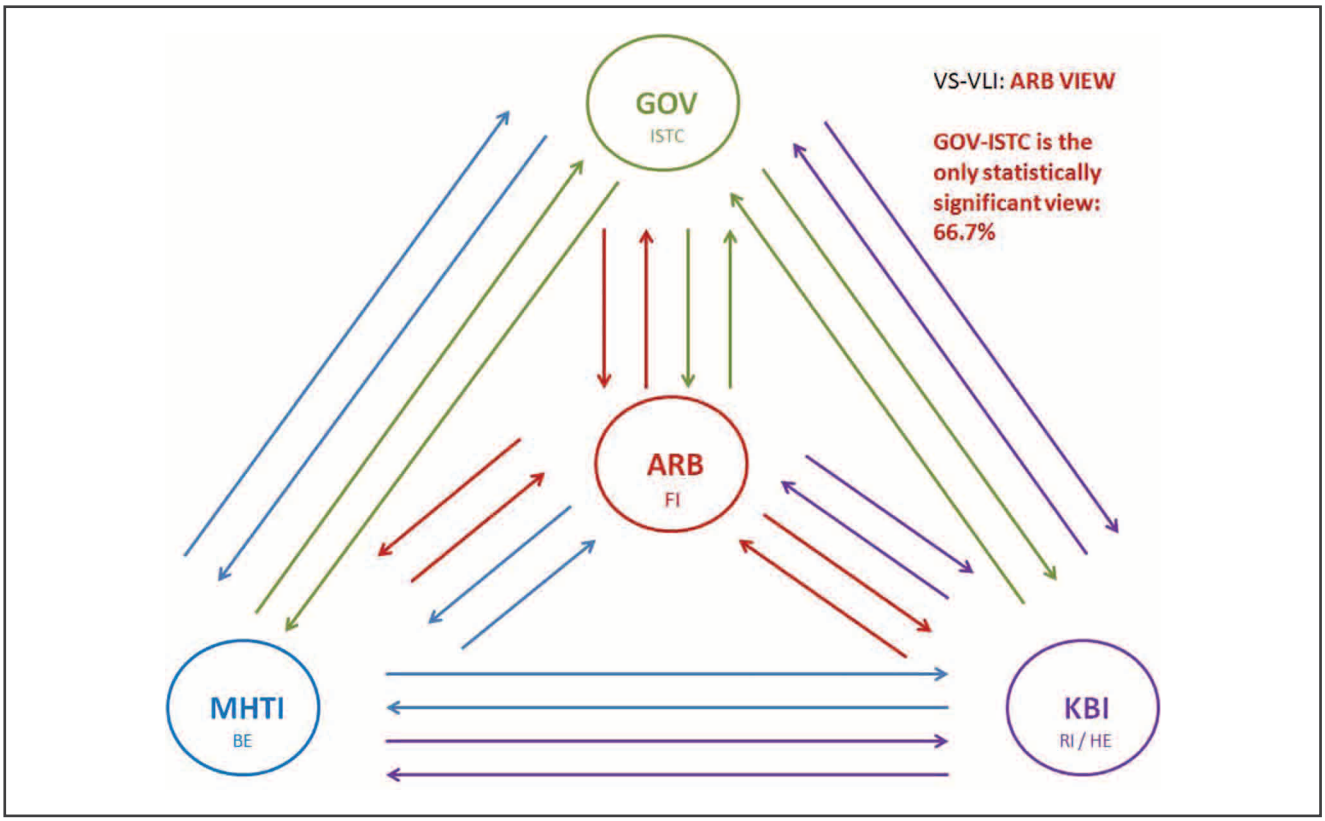


***Figure 9.20** – Arbitrageur View of Linkages and Level of Innovativeness – VS-VLI)*




**UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION**
Vienna International Centre
P.O. Box 300, 1400 Vienna, Austria
Telephone: (+43-1)26026-0, Fax: (+43-1) 26926-69