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Measuring National Systems of Innovation in Developing Countries: The Case of Ghana

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Abstract: National Innovation Systems (NSI) have become more central in economic and development studies in the past two decades. In our analysis we provide a systemic assessment and analysis of the NSI in terms of the interactions of its actors (according to a four-actor 'triple helix' model, comprising government, enterprises, knowledge institutions, and arbitrageurs). This is carried out through cross-tabulation of the data obtained from the Ghana National System of Innovation (GNSI) Survey conducted by the United Nations Industrial Development Organization (UNIDO). Our results show significant deficiencies in the inter- and intra-linkages among actors. These constitute the barriers in the GNSI.

Keywords: National Innovation System; Triple-Helix Type 4; Ghana; Government; MHT Enterprises; Knowledge Based Institutions; Arbitrageurs; UNIDO.

Introduction

National Systems of Innovation (NSI) have gained wide consensus due to knowledge flows in economic development and increasing reference to a systemic approach in the literature (Achim and Popescu, 2009). The OECD (1997) recognised the importance of public research institutions (RIs) and their links to industry as crucial national assets for innovation. Recent NSI analyses (Balzat and Hanusch, 2004; Cai, 2011; Guan and Chen, 2012) have led to better understanding of NSI for policy prescriptions. However, the relationship between conceptual and empirical studies of NSI is generally weak

(Fagerberg and Srholec, 2008). Industrial countries have similar structures for innovation but they differ substantially in how innovation actors interact, and therefore in the structure of underlying systems (Lee and von Tunzelmann, 2005).

A nation's innovative performance is based on how effectively and efficiently NSI actors interact as elements of a collective system of knowledge creation and application (Liu and White, 2001; Kaufmann and Tödtling, 2001; Nelson and Nelson, 2002 Motohashi, 2005; Pan et al., 2010). We aver that it is important to focus on the dynamics of NSI in terms of interactions among four key actors – Government, Industry, Knowledge-based Institutions (KBIs) and Arbitrageurs - to better understand how the NSI can functionally improve and yield economic development.

Focusing on inter- and intra- relational dynamics of the four actors has yet to gain widespread research attention (Sharif, 2006). Generally, advanced countries are increasingly specifying NSI policies[1]. Developing countries have also recognized the value of the NSI for dynamising their economies[2]. The purpose of this paper is to assist in filling the empirical and measurement gap in the literature, focusing on the systemic aspect of NSI rather than on single aspects of innovation as most of the current empirical work (Becheikh et al., 2006). The rest of the paper is organized as follows. Section 2 - Literature review – presents key concept of NSI, its definition, and the actors involved. Section 3 – Methodology – describes the sample of respondents, methodological issues and survey analysis. Section 4 – Results and discussion – discusses l results in terms of policy analysis and implications. Section 5 – Concluding Remarks – concludes with policy recommendations indicating issues for further research.

Literature review

The concept of National System(s) of Innovation (NSI) has been refined in the last three decades. The first modern notion of NSI, early 1980s, focused on the importance of long-term investment and economic development, recognizing the need for long-term investment in 'mental capital' as the key for economic development (Freeman, 2004). At its earliest stage, literature on NSI recognized the importance of linkages among science, technology, trade and industry (Freeman, 2004). The efficiency of NSI is heavily influenced by the intensity of inter- and intra-organisational relationships between, and within, actors. A definition of NSI therefore includes elements that interact in shaping innovation processes alongside linkages between innovation and economic performance (Lundvall, 2007).

NSI is the combination of institutional networks that implement, lead or import innovation, relations that produce and diffuse new techno-economic information, and the dynamic system that conforms information, regulation and finance flows between institutions and firms (Sakaraya, 2011). Institutions have a dual role, as organizations and as 'rules of the game' (North, 1991); their role within NSI can be seen as that of 'stocks'

[1] See, for example, the EU community Innovation surveys, and open source in developing countries (SIDA, 2004)

[2] See, for example, National Science, Technology and Innovation Plan 2012/2013 – 2017/2018, Ministry of Finance, Planning and Economic Development, The Republic of Uganda.

while flows are transfers of tacit know-how and codified knowledge. This implies that NSI consists of the spatial distribution of linkages and their intensity between institutions that facilitate intellectual flows and exchanges of knowledge at a formal and informal level (Buckley and Carter, 2004).

The evolution of NSI definitions exhibits recurring elements, e.g. knowledge transfers, skills, interaction and learning (Koria and Koszegi. 2011). Considering NSI an envelope of conforming policies (Bartels et al., 2012) implies a development in the meaning to include the effects of diffused ICT and arbitrageurs. The spread of ICT and digital information has triggered new modes of development (Freeman and Louça, 2001). The digital divide is attributable to issues of storage, ability to compute and transit digital information in relation to the key four actors of NSI (Hilbert et al., 2010).

According to our survey of the literature, and Lundvall (2007), while work on innovation is profuse, there is little empirical work on NSI. What is available focuses at firm level (Chaminade et al, 2012; Adams et al, 2013). It is crucial to understand that NSI is nested in institutions that shape behaviour and relationships (Manjón and Merino, 2012). Empirical evidence shows the contribution of knowledge transfers to higher productivity and economic growth (Cohen et al., 2002; Mueller, 2006). Nonetheless the majority of firms do not collaborate with universities (Bodas Freitas et al., 2013). This paper analyses a triple-helix type 4 model, namely the relationships between Government, Business Enterprises (BEs)[1], KBIs, and Arbitrageurs.

Methodology

Sample, respondents and survey

The GNSI survey maps and measures the perceptions of NSI of high-level executives in government (GOV), medium and high-technology industry (MHTI), KBIs, and Arbitrageurs (ARB).[2]

Table 1 summarizes the survey universe, convenient sample and respondents. Response rates are valid and reliable given that for senior management response rate is typically 30%.[3]

[1] That is the medium- and high-technology industrial manufacturing in accordance with UNIDO ISIC Rev. 3 classification.
[2] Comprising Financial Institutions (FIs), Venture Capitalists/Knowledge Brokers.
[3] See Harzig, 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.

Table 1 GNSI Universe and distribution of survey returns by Actor

Actors	*Universe of Respondents*	*Convenient Sample*	*Responses*	*Response Rate (%)*
Government	260	166	39	33.6
MHT Industry	120	87	60	68.9
KBI	182	175	129	73.3
Arbitrageurs (Venture Capitalists/ Knowledge Brokers)	16	16	6	37.5
All Actors	578	444	234	52.7

Source: Authors' elaboration of survey data

The policy community is represented by high-level officials responsible for innovation in ministries of trade and industry, science and technology, economy, finance, education, interior, and regional ministries. KBIs are represented by heads of universities, and innovation-related faculties/departments in higher education (HE), think-tanks and RIs. The industrial community (BE) is represented by the Chief Executive officers (CEOs) of firms in MHTI manufacturing. Arbitrageurs - Financial Institutions (FIs), Knowledge brokers and Venture Capitalists - are not part of the traditional triple helix model but their inclusion is vitally important as they assess competitive advantages in information asymmetries, allocate resources and act as intermediaries (Williamson, 1973), allowing firms to improve their performance and survival rates (Zook, 2003; Hargadon, 1998).

Survey variables were developed from NSI literature. Delivering the survey electronically allowed: surveying a larger number of respondents; faster time; higher quality of retrieved data; higher reliability of data as the survey is the data, therefore avoiding data entry error. The level of computer access of the target population is critical to web-based surveys, in the case of GNSI the population is one with very high internet access (Koria et al., 2012).

The GNSI survey instrument yielded quantitative data on five dimensions of the NSI: Constitution, Components, Barriers to Innovation, Policy Processes, and Innovative Performance. The perceptions of respondents in these dimensions were along a five point Likert-scale (Clason and Dormody, 1994). To assure high reliability and validity, test-retest questions were used (Easterby-Smith at al., 2012). Intra-observer reliability was ensured by repeating questions, allowing consistency and significance of responses to be validated through statistical analysis.

The survey was conducted electronically using Free Open Source Software (FOSS) Lime Survey; and to ensure that the Respondents were the Actors for the questionnaire links to the survey were tokenized so that none but the recipients could open them.

Survey Analysis

The variables selected for analysis are actor importance and their linkages. Analytical results are based on cross-tabulations, reported at or above a 95% confidence level. Cross tabulation allows the observation of statistically significant relationships within data. Our analysis concerns the importance of GNSI and systematic relationships between

variables. Significance of results is ensured by running Chi-square test of significance indicating the high level of probability of evidence in support of systematic relationships between variables. Moreover, if the survey were repeated longitudinally, similar systemic relationships would be found. Hence, if the Chi-square probability value is lower or equals 0.05, there is a significant systematic relationship between the NSI variables.

The significance reported provides high confidence in the results and assures meaningfulness regarding robust policy craft. In the cross-tabulations the five point of the Likert-scale is dichotomized into the limits of the measurement scale. Neutral was assigned to the negative side of the scale based on the contention that neutral perceptions by experts are not positive from a policy perspective.

Results and Discussion

Our analysis focuses on deficiencies and proficiencies of NSI in order to better orient policy makers towards policy implications and recommendations. It is possible to see how available resources may be applied more effectively to address relevant deficiencies and strengthen proficiencies.

The analysis concerns the system's internal relationships. The results are a view of the system's structure and actors' behaviour, thus of its efficiency in part and effectiveness as a whole. Results are limited to the strength of the actors' inter- and intra-linkages and concern selected variables in GNSI. The results are reinforced by analysing individual sets of actors and unless otherwise stated the results from all respondents (ALL) are reported.[1] Not all figures sum up to 100% due to round up, cross-tabulation and particular analytical perspectives.

RIs Linkages with the Production System and level of innovativeness of BEs

RIs have a pivotal innovation role, considered as a dynamic function of knowledge research, science and technology, and innovativeness in the production system of the economy (Gordon, 2012).

Regarding the linkages between RIs and the production system, 91.9% of ALL Respondents indicate very low levels of innovativeness of BEs; only 3.9% indicate very strong linkages and very high levels of innovativeness of BEs. Regarding the linkages between RIs and the production system, which 82.6% of ALL Respondents deem very weak with very low levels of innovativeness in BEs; only 9.3% of ALL Respondents assess these linkages as very strong but with very low levels of innovativeness in BEs. This finding is robustly supported by MHTI and KBI, respectively 90% and 95.5% of whom indicate very low levels of innovativeness in BEs. Only 10.0% of MHTI and 2.4% of KBI Respondents evaluate RIs linkages with the production system as very strong with very high levels of innovativeness in BEs.

Policy implications of truncated RIs-production system linkages, and the very low levels of innovativeness of BEs are:

- there appears at best very few, at worst no, externalities from RIs as public goods;

[1] Respondents and Actors are used interchangeably in this paper.

- the signalling mechanisms by which RIs respond to markets and the production system, and BEs make demands on RIs appear at best intermittent, at worst dysfunctional;
- the marketing and sales posture of RIs regarding intellectual property stocks seems feeble, therefore their exploitation of knowledge assets is likely very limited;
- intellectual property flows from RIs to the production system seem stymied; and
- potentials for RIs to earn license, patent, and royalty fees from internally generated intellectual property rights are largely unrealised.

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

Firstly, we examine the relationship between the importance of GNSI Actors and the strength of inter- intra-Actor linkages. Secondly, whether the linkages are strong or weak from each Actor's perspective. Finally, the view of the linkages of other Actors from each Actor's perspective (Actor-centric view) is examined. Results are reported as very important-very strong (VI-VS) and very important-very weak (VI-VW). The GNSI is analysed in terms of both All Actors and Individual Actors as Respondents, respectively in order to understand: Actors' significant perceptions; relative distribution (spread of linkages); density (number of linkages); and balance (uni-, bi-directional) of linkages within the GNSI.

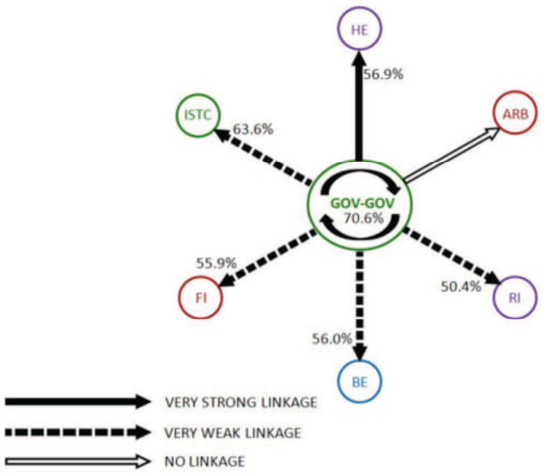

Figure 1 Government Inter-, Intra-Linkages.

GOV inter-, intra- Actor linkages are generally very weak with institutions supporting technical change (ISTC), BEs, FIs and RIs (Figure 1). GOV has no significant relationship with ARBs; there are strong GOV-GOV and GOV-HE linkages. Considering an individual Actor perspective, concerning GOV-GOV intra-linkages, 66.7% of ARB Respondents perceive GOV-ISTC as VI-VS, as opposed to KBI Respondents 56.6% of which perceive GOV-ISTC as VI-VW. GOV-ISTC is perceived as VI-VW by 46.3% of

GOV Respondents. A crucial finding is that there is no statistically significant assessment by GOV Respondents of the inter-linkages among other Actors in the GNSI regarding importance of Actor and strength of linkages (Figure 2).

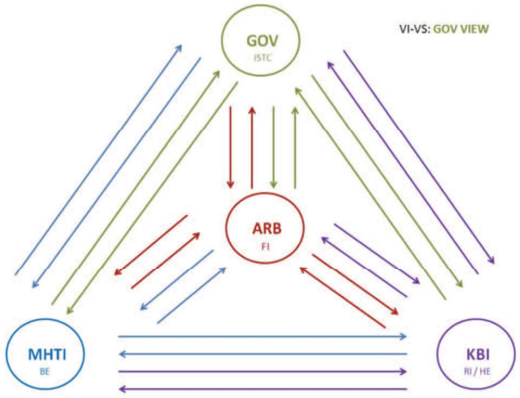

Figure 2 Government Assessment of Other Actors' Inter-Linkages.

At policy level, these findings imply that GOV appears at worst to have little idea, at best a truncated view, of the pertinent systemic relationships key to innovation in the national economy. GOV truncated view occludes the variables of, and priorities in, policy for the overall governance of the NSI in terms of:

- Government actions and STI coordination funding;
- STI organisations stability (human capital, funding support);
- Institutionalising evidence-based policy-making (GNSI Survey applied longitudinally as an advanced assessment, monitoring and evaluation method for managing the NSI);
- Policy instruments evaluation; and
- Catalysing higher networking densities across GNSI.

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

There is only one significant linkage with ARB from the perceptions of ALL Respondents regarding BE inter-, intra-Actor linkages and is perceived as very weak. However, very strong linkages are found between BE-BE (Figure 3).

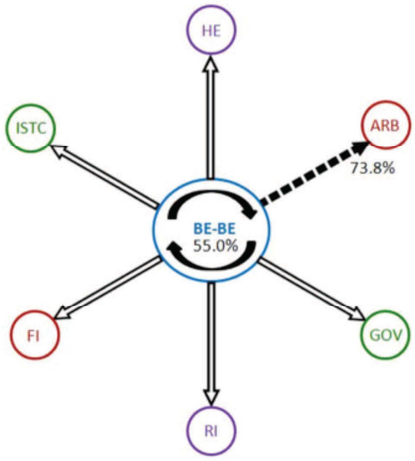

Figure 3 BEs Inter-, Intra-Linkages.

Concerning BE-BE intra-linkages, from an individual Actor perspective, 51.7% of MHTI Respondents perceive BE-BE as VI-VS. For MHTI Respondents, in the minority (<50%) the distribution of VI-VS Actor linkages is ARB centric (Figure 4). There is a significant bi-directional relationship between GOV-KBI, while linkages between ARB, KBI and GOV are unidirectional. Interestingly there is no significant perception of bi-directional linkages between KBI-GOV.

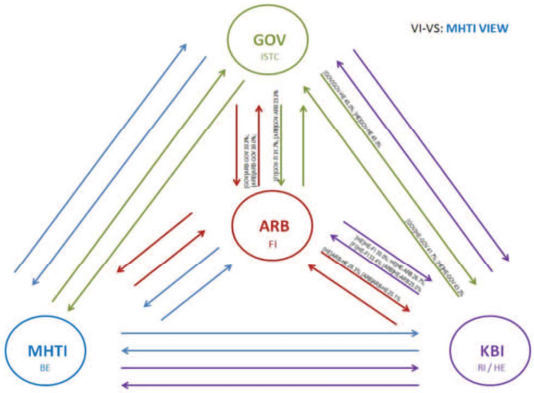

Figure 4 Medium and High-Tech Industry Assessment of Other Actors' Inter-Linkages.

At policy level the relative isolation of BEs from other Actors implies that industry in general appears at best poorly able, at worst powerless to, influence design, calibration and articulation of policy instruments to promote and accelerate business research, development and institutional innovation. In these conditions BEs are unlikely to:

- Inspire the setting of public procurement policy;

- Encourage GNSI Actors, and ISTC and industry associations, cooperation and collaboration;
- Prominently influence the GNSI (strategic disposition, orientation and policy priorities);
- Project constraints to Government;
- Review innovation-related regulatory regimes that govern the relationship between public resources and the private sector;
- Assist in removing obstacles and impediments to public private-sector partnerships for innovation initiatives; and,
- Fully converge with Government priorities concerning demand-signals, and fostering human capital mobility from BE to GOV (and vice versa).

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

For ALL Respondents, HE and RI inter-, intra-Actor linkages are generally very weak. More so concerning HE inter-linkages with ARBs, FIs, ISTC and BEs (Figures 5 and 6). There are no significant relationships between FIs, ARBs, ISTC and BEs concerning RIs. Very strong linkages are found between HE-GOV and HE-RI. Pertaining to RI inter-linkages, RI-HE is very strong while RI-GOV is very weak.

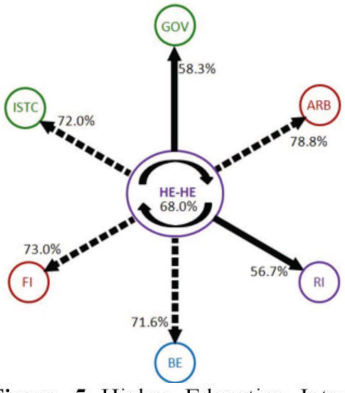

Figure 5 Higher Education Inter- Intra-Linkages.

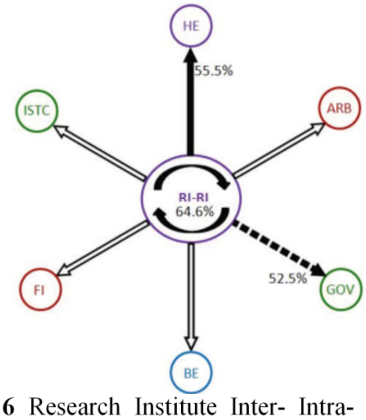

Figure 6 Research Institute Inter- Intra-Linkages.

Concerning HE-HE intra-linkages, from an individual Actor perspective, 48.2% of MHTI Respondents perceive HE-HE as VI-VS; for RI-RI intra-linkages, 67.5% of KBI Respondents perceive RI-RI as VI-VS; and concerning RI-HE/HE-RI intra-linkages, 61.3% and 59.8% of KBI Respondents perceive RI-HE and HE-RI respectively as VI-VS. Regarding KBI Respondents, the minority (<50%) finds the distribution of VI-VS

Actor linkages ARB centric (Figure 7). The linkages are perceived as unidirectional. No significant perception of the linkages between MHTI and GOV by KBIs is present.

At policy level these findings imply that KBIs appear at best poorly able, at worst unable, to tap into and exploit available stocks and flows of knowledge. Their intermediation role has significant limitations (their ability to influence innovation policy is reduced). KBIs seem unable to:

- Contribute significantly to research and development networks;
- Manage effectively the supply-side of advanced human capital resources, and Data, Information, Statistics and Knowledge (DISK) to MHTI;
- Respond effectively to demand-side human resource requirements from MHTI;
- Set priorities in specialization;
- Develop inter-HE institutional competitiveness;
- Develop pedagogic and curricula programmes that serve other Actors, especially MHTI;
- Align competitive enhancement of KBIs with regional development priorities; and,
- Strategically develop KBIs' capacities and capabilities.

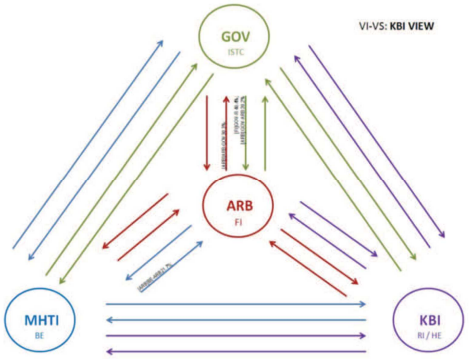

Figure 7 Knowledge-Based Institution Assessment of Other Actors' Inter-Linkages.

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

From the perceptions of ALL Respondents regarding ARB inter-, intra-Actor linkages, there is only one significant linkage with GOV, perceived as very weak (Figure 8). ARB-ARB intra-linkages are perceived as very strong. ARB-FI intra-linkages are VI-VS for 45.8% of KBI Respondents and 44.9% of MHTI Respondents.

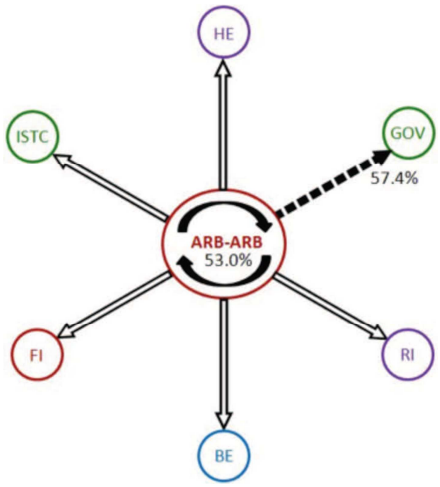

Figure 8 Arbitrageurs Inter- Intra- Linkages.

From the perspective of ARB Respondents, the distribution of VI-VS Actor linkages is GOV centric with a perception of a significant bi-directional relationship between GOV-KBI (Figure 9).

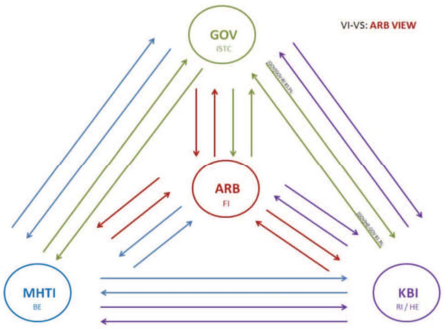

Figure 9 Arbitrageur Assessment of Other Actors' Inter- Linkages.

At policy level these findings imply that Arbitrageurs, pivotal intermediary institutions, appear at best to be performing poorly their intermediation role. In particular arbitrageurs appear:

- Limited intermediaries, because of isolation from KBIs;
- Debilitated in linking ISTC to BEs via private equity; and
- Occluded from increasing technological capacity of BEs through knowledge brokering.

Government [GOV] [ISTC] Inter-, Intra-Linkages and Level of Innovativeness of BEs

As a key actor of the NSI, GOV should have very strong and significant links with other Actors. However, over 91.7% of ALL Respondents indicate very low level of innovativeness of BEs. Remarkably only 5.1%-6.9% of ALL Respondents assess GOV inter- and intra-linkages as very strong and level of innovativeness of Bes as very high. Even though a range of 20.6% to 57.7% of ALL Respondents indicate very strong GOV inter- and intra-linkages, they also indicate a very low level of innovativeness of BEs. Strikingly, between 34.3% and 71.3% of ALL Respondents indicate that GOV inter- and intra-linkages as very weak and Bes' level of innovativeness as very low. Regarding the crucial GOV-BE linkages 92.1% of ALL Respondents indicate very low levels of innovativeness in BEs and only 5.6% indicate Very Strong-Very High Innovativeness in BE. Interestingly, 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 crucial, as it suggests that GOV has no significant assessment of other Actors' inter-, intra-linkages (Figure 10).

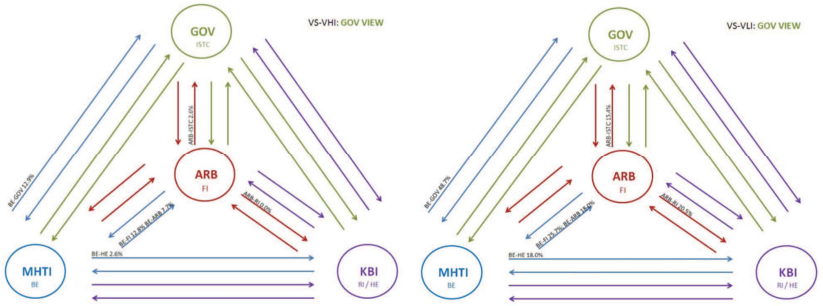

Figure 10 Government View of Linkages and Level of Innovativeness – VS-VHI/ VS-VLI.

48.7% of GOV Respondents indicate very strong linkages between BE-GOV and a very low level of innovativeness of BEs. Moreover, 15.4% of GOV Respondents indicate ARB-ISTC VS-VLI. However, GOV Respondents do not have a statistically significant view on KBI-GOV linkages or on GOV-KBI linkages. 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) of Government linkages. 18.4%-40.0% of MHTI Respondents view GOV linkages with other actors (and itself) as VS-VLI (Figure 11). In contrast, 50.0%-71.7% view GOV linkages as VW-VLI. 36.6% - 48.2% of KBI indicate GOV linkages with other Actors (and itself) as VS-VLI (Figure 12), while 47.4% to 59.0% of KBIs indicate GOV linkages as VW-VLI. 66.7% of ARB indicates GOV linkages with itself (ISTC) as VS-VLI (Figure 13), while 16.7% view GOV linkages as VW-VLI. At policy level these findings imply that:

- Government appears not to have, at-hand, means and instruments to map and measure the GNSI for policy assessment, monitoring, evaluation and adjustment;
- The isolation of GOV from the GNSI, regarding inter-linkages, deemed very strong only with HE (a traditional link) and very weak with other Actors (none with ARB) presents a serious challenge to creating a higher performance NSI;

- Issues of under-leveraged legislative power, muted policy dialogue, and competitive divergence below potential frontier EMEs arise.

The finding of a statistically significant assessment of very low levels of innovativeness, irrespective of the strengths of Government inter-linkages further implies that:

- Government command over the innovation environment (policy regulation and performance requirements) does not foster threshold levels of innovativeness by other Actors;
- The Government's legislative power is not leveraged enough to increase higher resolution standards in the supply-side for goods and services provision;
- The Government's calibration of the policy environment is insufficient to encourage systemically higher innovativeness levels;
- The Government's role as prime driver of the economy (procurement modalities, legislation and regulation) in encouraging innovativeness and innovation among early adopters and early majority in the diffusion of innovation paradigm is not fully utilised; and,
- Very weak Government linkages at best mute, at worst disable, the policy dialogue among GNSI Actors;

BEs [MHTI] Inter-, Intra-Linkages and Level of Innovativeness of BEs

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% of ALL Actors indicate very strong BE linkages with other Actors and very high level of innovativeness of BE. Notably, 48.7% of GOV Respondents indicate very strong linkages between BE-GOV and a very low level of innovativeness in BE. 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 (Figure 11). 18.0%-48.7% of GOV Respondents view BE linkages as VS-VLI. However, 11.7%- 18.4% of MHTI Respondents view BE linkages as VS-VLI. 21.1%-37.2% of KBI Respondents indicate BE linkages as VS-VLI, while 58.2%-74.5% view BE linkages as VW-VLI. While 48.7% of GOV Respondents and 37.2% of KBI Respondents judge BE-GOV as VS-VLI. With reference to industry only 18.4%, and 11.7% MHTI Respondents respectively perceive BE-HE and BE-RI as VS-VLI.15.0% perceive RI-BE as VS-VLI.

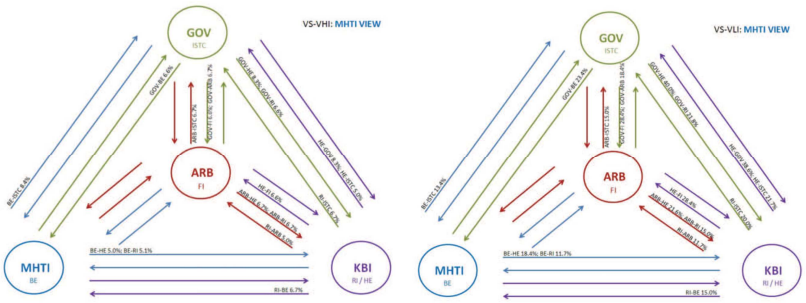

Figure 11 Medium and High-Tech Industry View of Linkages and Level of Innovativeness – VS-VHI / VS- VLI.

Policy implications regarding BEs inter- and intra-linkages and very low level of innovativeness in BEs are of particular concern as innovation is manifest mostly in industries (supply-side) and markets (demand-side):

- MHTI has little, if any, access to sources of innovation other than its own R&D expenditure and efforts, as a consequence of BEs isolation from GNSI Actors;
- Exposure of BEs to DISK is reduced due to limited reciprocating relations with KBIs;
- The deficiency conveyed by the VW-VLI assessment should be viewed through the lens of the Government's partial and generally uneven command over the environment for innovativeness and innovation, which implies a lethargic regulatory dynamic for increasing standards and competition;
- The identification of 'promising local companies' and potential 'national champions' is obscured;
- Market signals concerning demand likely remain unnoticed; and,
- Opportunities for generating externalities through cross-cutting licensing and patenting, and concomitant fees are limited.

Higher Education [KBI] Inter-, Intra-Linkages and Level of Innovativeness of BEs

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. Specifically, concerning the key linkages between HE and BE 91.8% of All Respondents indicate very low levels of innovativeness of BE. Only 4% indicate very strong HE-BE linkages and very high levels of innovativeness of BE. This is confirmed by 89.9%-91.9% of MHTI Respondents suggesting very low levels of innovativeness of BE, irrespective of the strengths of HE inter- and intra-linkages. 5.0%-8.3% of MHTI Respondents indicate very strong HE inter- and intra-linkages and very high levels of innovativeness of BE. 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. Regarding ARB and ISTC only 2.4% of KBI indicate very strong HE inter-linkages with ARB and ISTC, and very high levels of innovativeness of BE (Figure 12). Remarkably, GOV Respondents do not have a significant view of HE intra-, and inter-linkages and level of innovativeness of BE. Moreover, concerning perceptions of KBIs regarding HE-ARB 15.9% indicate VS-VLI. Regarding perceptions of KBI regarding ARB-HE, 20.2% indicate VS-VLI. 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, while 71.6%-79.4% of KBIs indicate HE linkages as VW-VLI.

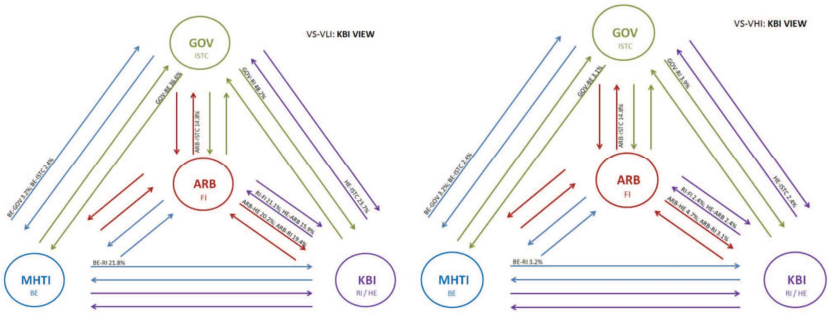

Figure 12 Knowledge-Based Institution View of Linkages and Level of Innovativeness – VS-VHI / VS-SLI.

As with GOV inter-, and intra-linkages and the level of Innovativeness of BE, HE inter-, and intra-linkages assessed as very weak concomitant with very low level of innovativeness of BE has serious policy implications. Specifically, these concern:

- The very weak HE inter-linkages with ARB, FI, ISTC, BE, implying that KBI DISK do not have sufficient outlets, through intermediation and commercialisation, to demand markets;
- KBIs relatively poor market intelligence capacity and capability, therefore little knowledge of market needs;
- KBI IPRs management system, likely to be remote from users and intermediaries;
- Research, likely to be tangential to the needs of MHTI; and,
- Incubation of spin-offs (in high technology) into SMEs, due to truncated opportunities for industry funded and sponsored R&D, and product development.

Arbitrageurs Intra-, Inter-Linkages and Level of Innovativeness of BEs

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

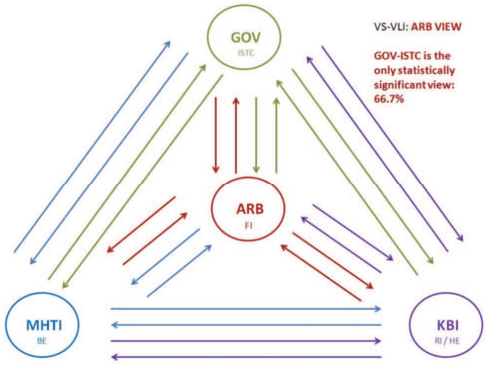

Figure 13 Arbitrageurs View of Linkages and Level of Innovativeness – VS-VLI.

15.4% of Government Respondents perceive linkages between ARB-ISTC (GOV) as VS-VLI. Additionally, concerning KBIs assessment regarding HE-ARB and RI-FI, respectively, 15.9% and 21.1% KBIs indicate VS-VLI. Regarding KBIs assessment of ARB-HE and ARB-RI linkages, respectively, 20.2% and 19.4% indicate VS-VLI. 15.0%-21.6% of MHTI Respondents estimate ARB linkages as VS-VLI. Yet, 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. Concerning ARB-HE and ARB-RI linkages, Industry, Government and KBI have similar perspectives. However, there is no significant assessment of ARB-BE link (Figure 13).

At policy level these findings imply:

- Unexposed stocks of knowledge, and truncated Arbitrageurs' DISK intermediation efforts from KBI to MHTI and BE.
- Very weak GOV-ARB inter-linkages, limited Arbitrageurs' influence on innovation policy concerning KBI and MHTI;
- Unexploited externalities-generating competitive advantages arising from information asymmetries extant between KBIs and other Actors;
- Arbitrageurs largely cut off from equity positions in potential start-up businesses, based either on KBI R&D outputs or spin-offs from KBI and MHTI; and,
- Largely missing role of linking the GOV-KBI and KBI-MHTI axes of the Triple Helix type 4.

Concluding Remarks and Issues for Further Research

The policy findings and recommendations concern:

- NSI linkages with production system and level of innovativeness of BEs;
- Importance of Actor and strength of inter- intra- actor linkages (for the four actors); and,
- Actors' inter-, intra- linkages and level of innovativeness of BEs.

The findings are that firstly there is an absence of significant very strong actor inter-, intra- linkages. Out of six inter-linkages only KBIs[HE] has two very strong inter-linkages (with government and RIs – these are traditional links). All other Actors have 83.3% of their interlinkages assessed as very weak or non-existent.

Secondly, according to All Respondents, at a finer grain - besides HIM and GOV-ARB nonexistent linkages – all other actors have several non-existent inter-linkages as follows:

- BEs have no significant links with GOV, RIs, FIs, ISTC and HE;
- RIs have no significant links with ARB, BEs, FIs and ISTC; and
- Arbitrageurs have no significant links with RIs, BEs, FIs, ISTC and HE.

Thus the GNSI is largely characterized, in terms of the triple-helix Type 4 model of interaction between Government, MHTI, KBIs and Arbitrageurs, by very weak, perforated and truncated or absent linkages. The few inter-linkages present are asymmetric in distribution and presage low density relationships. We find that the crucial linkages between RIs (the principle sources of ideation and invention) and the production system are largely absent. This separation when coupled with the isolation of Government, BEs, KBIs and Arbitrageurs from each other creates serious dysfunctions. The traditional relationships within KBIs and with Government, found to be very strong, result in few externalities.

Thirdly, concerning Actor linkages and level of innovativeness of BEs, all four actors have extremely weak inter-, and intra-linkages and very low levels of innovativeness are apparent.

The findings point to the following policy recommendations:

- reform governance in RIs (and KBIs) to enhance excellence in research based on performance measures tied to the funding of RIs and KBIs;
- shift in 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;
- re-orient funding of RIs and KBIs toward competitive grants tied to RIs and KBIs – MHTI relationships;
- require RIs and KBIs to create intellectual property rights (IPRs) management offices funded on performance, e.g. on in-coming LPRs;
- require science, technology, engineering, mathematics and information technology (STEMIT) doctoral and post-doctoral studies funded by Government scholarships to be embedded in MHTI firms;

- selectively tie fiscal and monetary incentives available to MHTI to the hiring of STEMIT post-graduates and embedding of doctoral and post-doctoral studies;
- allow RI and KBI researchers to commercially exploit discoveries through amended contract conditions;
- increase management autonomy of RIs and KBIs and the autonomy of their relationships to MHTI;
- require boards of RIs and KBIs to include CEOs from MHTI;
- fund RIs and KBIs research programmes within a competitive grants based on triangulation framework (KBI-RI-MHTI consortia) aimed at increasing multidisciplinary R&D;
- create a STEMIT Human Capital Mobility Fund incentivizing the movement of STEMIT personnel from RIs and KBIs to MHTI and vice versa; and,
- reform STEMIT curricula and courses to include an industry placement component ('thin' or 'thick' sandwich of three or six months per academic year).

Issues for further research involve analyzing the GNSI in terms of the factor barriers to innovation and policy success as well as cross country comparison of NSI in developing countries.

References

Achim, Ioan Moise and Teodora Popescu (2009). "The systemic approach to national innovation systems in a knowledge-based economy." *Annales Universitatis Apulensis Series Oeconomica*, 11, no. 2:946-952.

Adams, Pamela, Roberto Fontana, and Franco Malerba (2013). "The Magnitude of Innovation by Demand in a Sectoral System: The Role of Industrial Users in Semiconductors." *Research Policy* 42:1-14.

Balzat, Markus and Horst Hanusch (2004). "Recent Trends in the Research on National Innovation Systems." *Journal of Evolutionary Economics* 14:197-210.

Bartels, Frank L, Hinrich Voss, Suman Lederer and Christopher Bachtrog (2012). "Determinants of National Innovation Systems: Policy Implications for Developing Countries." *Innovation: Management, Policy & Practice* 14 (1):2-18

Becheikh, Nizar, Réjean Landry and Nabil Amara (2006). "Lessons from Innovation Empirical Studies in the Manufacturing Sector: A Systematic Review of the Literature from 1993-2003." *Technovation* 26:644-664.

Bodas Freitas, Isabel Maria, Aldo Geuna and Federica Rossi (2013). "Finding the Right Partners: Institutional and Personal Modes of Governance of University-Industry Interactions." *Research Policy* 42:50-62.

Buckley, Peter J. and Martin J. Carter (2004). "A Formal Analysis of Knowledge Combination in Multinational Enterprises." *Journal of International Business Studies* 35:371-384.

Cai, Yuezhou (2011). "Factors Affecting the Efficiency of the BRICS's National Innovation Systems: A Comparative Study Based on DEA and Panel Data Analysis". Economics Discussion paper no. 2011-52, Kiel Institute for the World Economy
http://www.economics-ejournal.org/economics/discussionpapers/2011-52

Chaminade, Cristina, Patarapong Intarakumned and Koson Sapprasert (2012). "Measuring Systemic problems in national innovation systems: An application to Thailand." *Research Policy* 41:1476-1488.

Clason, Dennis L. and Thomas J. Dormody (1994). "Analyzing data measured by individual Likert-type items." *Journal of Agriculture and Education* 35 (4):4-35.

Cohen, Wesley M., Richard R. Nelson and John P. Walsh (2002). "Links and Impacts: The Influence of Public Research on Industrial R&D." *Management Science* 49(1):1-23.

Easterby-Smith, Mark, Richard Thorpe and Paul Jackson (2012), 4th ed. *Management Research*. London: SAGE Publications Ltd.

Fagerberg, Jan and Martin Srholec (2008). "National Innovation Systems, Capabilities and Economic Development." *Research Policy* 37:1417-1453.

Freeman, Christopher (2004). "Technological Infrastructure and International Competitiveness." *Industrial and Corporate Change* 13(3):541-569.

Freeman, Chris, and Francisco Louçã (2001). *As Time Goes By: From the Industrial Revolutions to the Information Revolution: From the Industrial Revolutions to the Information Revolution.* Oxford: Oxford University Press.

Gordon, Robert J. (2012). "Is U.S. Economic Growth Over? Faltering Innovation Confronts the six Headwinds." NBER Working Paper 18315, August.

Guan, Jiancheng, and Kaihua Chen, (2012). "Modeling the Relative Efficiency of National Innovation Systems." *Research policy*, 41:102-115.

Hargadon, Andrew B., (1998). "Firms as Knowledge Brokers: Lessons in Pursuing Continuous Innovation." *California Management Review*, 40(3):209-227.

Hilbert, Martin, Priscila López and Cristián Vásquez (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):157–178.

Kaufmann, Alexander and Franz Tödtling, (2001). "Science-Industry Interaction in the Process of Innovation: The Importance of Boundary-Crossing between Systems." *Research Policy* 30(5):791–804

Koria, Ritin, Francis. L. Bartels, Sabine Koeszegi and Simone Carneiro, (2012). "Free Open Source Software (FOSS) and Survey Methodologies: The case of the Ghana National System of Innovation Survey." IST-Africa 2012 Conference Proceedings, IIMC International Information Management Corporation.

Koria, Ritin and Sabine Koeszegi (2011). "National Systems of Innovation (NSI): Measurement and Implications for Science Technology and Innovation Policy in Ghana." IN: *International Policy Conference Proceedings*, Competitiveness and Diversification: Strategic Challenges in a Petroleum-Rich Economy. Accra, Ghana 14-15th March,

Lee, Ting-Lin and Nick von Tunzelmann (2005). "A Dynamic Analytic Approach to National Innovation Systems: The IC Industry in Taiwan." *Research Policy* 34:425-440.

Liu, Xielin and Steven White (2001). "Comparing Innovation Systems: A Framework and Application to China's Transitional Context." *Research Policy* 30:1091-1114.

Lundvall, Bengt-Åke (2007). "National Innovation Systems – Analytical Concept and Development Tool." *Industry and Innovation*, 14:95-119

Manjón, Juan Vicente García and Elena Romero Merino (2012). "Innovation systems and policy design: The European experience." *Innovation: Management Policy & Practice* 14:33-42.

Mueller, Pamela (2006). “Exploring the Knowledge Filter: How Entrepreneurship and University-Industry Relationships Drive Economic Growth.” *Research Policy*, 35:1499-1508.

Motohashi, Kazuyuki (2005). “University-Industry Collaborations in Japan: The Role of New Technology-Based Firms in Transforming the National Innovation System.” *Research Policy*, 34:583-594.

Nelson, Richard R. and Nelson, Kathrine (2002). “Technology, Institutions and Innovation Systems.” *Research Policy*, 31: 265-272.

North, Douglas C. (1991). “Institutions, Institutional Change and Economic Performance. Political Economy of Institutions and Decisions.” St. Louis: Washington University.

OECD (1997). “National Systems of Innovation: Background Report.” Report DSTI/STP/TIP(97)2/, Paris: OECD.

Pan, Ta-Wei, Shiu-Wan Hung, and Wen-Min Lu (2010). “DEA Performance Measurement of the National Innovation System in Asia and Europe.” *Asia-Pacific Journal of Operational Research* 27(3):369-391.

Sakaraya, Orçun A. (2011). “Institutions’ and Initiatives’ Role in Turkey’s National Innovation System.” *International Business & Economics Research Journal* 10(3):29-39.

Sharif, Naubahar (2006). “Emergence and Development of the National Innovation System Concept.” *Research Policy* 35:745-766.

Williamson, Oliver E. (1973). “Markets and Hierarchies: Some Elementary Considerations.” *American Economic Review* 63(2):316-325.

Zook, Matthew A. (2003). “The Knowledge Brokers: Venture Capitalists, Tacit Knowledge and Regional Development.” DRUID (Danish Research Unit on Industrial Dynamics), Summer Conference on Creating, Sharing and Transferring Knowledge - The Role of Geography Institutions and Organizations. Copenhagen, 12-14 June 2003.