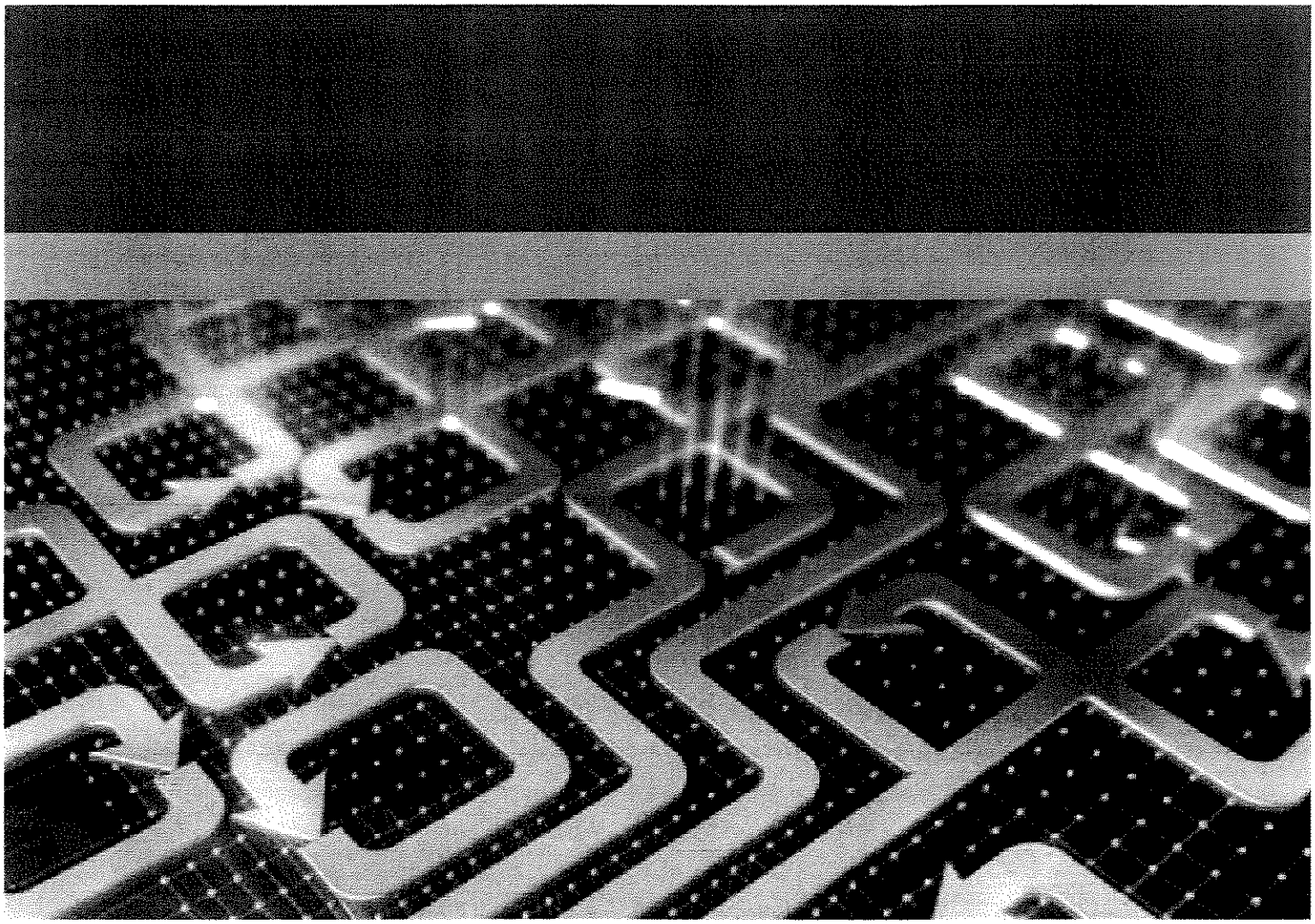


International Policy Conference Proceedings

Competitiveness and Diversification: Strategic Challenges in a Petroleum-Rich Economy

14-15th March 2011, Accra, Ghana

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION

International Policy Conference Proceedings

Competitiveness and Diversification:
Strategic Challenges in a Petroleum-Rich Economy

14-15th March 2011, Accra, Ghana

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION

Contents

13. National Systems of Innovation (NSI): Measurement and implications for science technology and innovation policy in Ghana

Ritin Koria, UNIDO, Vienna, Austria
Sabine Köszegi, Vienna University of Technology, Vienna, Austria

Abstract

This paper highlights the increasing significance of the systemic approach to innovation within the setting of knowledge based economies. In addition, the paper explains the crucial role of measurement and monitoring for the formulation of coherent, evidence based science, technology and innovation policy. The example provided in this paper is UNIDO's remote methodology to measure the Ghanaian National System of Innovation (GNSI).

1. Introduction

The increased importance being placed on the characteristics of country rankings and relative competitive positions within the global knowledge based economy has lead to knowledge production and transfer being considered key mechanisms for economic and competitive advancement (European Research Council Expert Group, 2003). Knowledge organized in its embodied and disembodied forms not only refers to the codifiable and explicit understanding that can be transferred extrinsically by technology, hard copy and skills, but also to the tacit and implicit components of understanding held intrinsically in individuals, organizations, collective experience and epistemic communities of practice.

This knowledge production and transfer are crucial determinants of an economy's ability to increase its competitiveness (relative to others) and diversify the depth and breadth of its primary, secondary and tertiary sectors in terms of increasing value-added (Bartels and Lederer, 2009).

The latter forms, because of their idiosyncratic and intrinsic nature, may not be readily codified, replicated or transferred across inter- or intra-organizational boundaries. As stated by Oyelaran-Oyeyinka (2005, p. 5) "[...] technological knowledge is crucial to development. However, designing the right social institutions to absorb, retain, advance and sustain knowledge has turned out to be more challenging". In addition to understanding the importance of codified and tacit knowledge, it is also important for governments concerned with competitiveness to efficiently utilize policy instruments and internal resources (economic agents and institutions) if they are to achieve competitive advantage through NSI.

As indicated by Leydersdorff and Ektowitz (1996), the characteristics of NSI—that is, the strength and quality of interactions between government, knowledge-based institutions (KBIs) and industry—are critical determinants of efficiency and effectiveness in the creation and dissemination of both tacit and codified knowledge. The advantages of being able to employ the skills of another is self-evident; however, the numerous and multifaceted institutional challenges and cultural difficulties that accompany this process at the scale of national economies may be neither entirely clear nor tractable.

The aim and objective of this paper is therefore to gain an enhanced understanding of the importance of the main actors' perspectives and interactions—as development assets—within the NSI of Ghana and provide a strong basis for their valid measurement for the development of policy to effectively achieve national targets.

The paper is structured as follows: Section 2—literature review—reviews the seminal literature on NSI and focuses on the model that informs the proposed method of measurement. Section 3—Ghanaian context—presents current governmental objectives and argues for the need to effectively measure the current system. Section 4—methodological approach—presents the measurement tool. Section 5—expected outputs—discusses the estimated results in terms of policy insights. Section 6—concluding remarks—concludes and presents issues for further research.

2. Literature review

The Systems of Innovation concept is seen as evolutionary (Lundvall, 2007) and has developed substantially from its early conceptualization and empirical framework through the seminal works of Pavitt (1984), Patel and Pavitt (1994) based on Friedrich List's concept of 'national systems of production' (List, 1841; Carlsson, 2006). The taxonomy of systems of innovation gives rise to four key areas of focus, namely: national, regional, sectoral and technological systems of innovation. Additionally, there are global systems of innovation (Archibugi and Iammarino, 1999), metropolitan innovation systems as defined by Fischer, Revilla-Diaz & Snickars (2001) and spatial

innovation systems elucidated by Malecki and Oinas (2002). The spatial overlap of these categorizations raises a number of issues concerning policy boundaries in terms of, *inter alia*, incentives, eligibility, the remit of implementing institutions and sources of performance success (or failure).

2.1. National systems of innovation

The rate of innovation and associated competitive advantage generated by NSI are dependant upon the way intra- and inter-organizational relationships are resourced and managed within cooperational and conflictual contexts which arise because of agency problems and management utility. This includes the relations between and within knowledge, information and skills as well as their interlinkages and reciprocating exchange of value. Concepts and explanations used to understand the dynamics of economic and social development through innovation are becoming more systemic (Antonelli, 1999; Cohendet et al., 1999). Their articulation is moving towards an understanding of networks and interactions as complex adaptive systems or 'self-organizing systems' with respect to properties of non-linear systems[1], knowledge generation and flows as opposed to linear models of demand 'pull' or 'technology push' (Nelson and Winter, 1982; Dosi et al., 1988; Leydesdorff and Van den Basselaar, 1994). NSI is one such phenomenon. Based on findings from the theoretical and empirical work at the 1999 conference on "National Innovation Systems, Industrial Dynamics and Innovation Policy" (DRUID, 1999), we can ascertain that within the taxonomy, NSI encompasses at least eight dimensions. These are: methodological; knowledge; learning; organizational, inter-industry and inter-firm linkages; growth and industrial renewal; NSI in developing countries; globalization and NSI; and NSI policy. These dimensions denote the evolution and dynamicism of NSI and shed some light on why considerable efforts have been made to measure the factors and variables of NSI performance at varying levels (meta, macro, meso and firm).

At the meta level, work carried out by Archibugi and Iammarino (1999) examines the global nature of NSI. This is further developed by Blanc and Sierra (1999) and Carlsson (2006) who highlight the increasing internationalization of alliances between firms or networks within the context of research and development activities.[2] Their findings highlight the important role KBIs play, namely universities, private and public research centres and international firms engaged in research based techno-scientific collaborations. These actors are the focus of Leydesdorf's (2001) "neo-evolutionary" model of university-industry-government interactions, known as the triple helix. Schoser (1999) provides a secondary perspective at the meta level and adds two dimensions to the categorization of NSI, namely the level of formality and distance from the innovation process. Informality is considered central to networking and the development of the social capital that lubricates the functioning of the NSI (Bartels, 2005). A characterization of NSI at the macro level leads us to the work of Bjørnskov and Svendsen (2002) who use decentrialization and social capital to demarcate the 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 its organizational nature 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 to characterize NSI reflect differing purposes of inquiry and focus. To further delineate the NSI approach we look at how the definition of NSI has evolved.[3]

- '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, pp.2)
- 'a set of institutions whose interactions determine the innovative performance [...] of national firms.' (Nelson and Rosenberg., 1993, pp.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, pp.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 of the goal of the interaction is the development, protection, financing or regulation of new science and technology.' (Niosi et al., 1993, pp.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, pp.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 artifacts which define new technologies.' (Metcalfe, 1995, pp.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, pp.7).
- 'The envelope of conforming policies as well as private and public institutional relations, and their coherent social and capital formations, that determine the vector of technological change, learning and application in the national economy' (Bartels, Voss, Bachtrog and Lederer, 2008, In press).

[1] According to Allen (2000, p.85) "Self-organisation is a natural property of real nonlinear systems".

[2] See also Dunning (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.

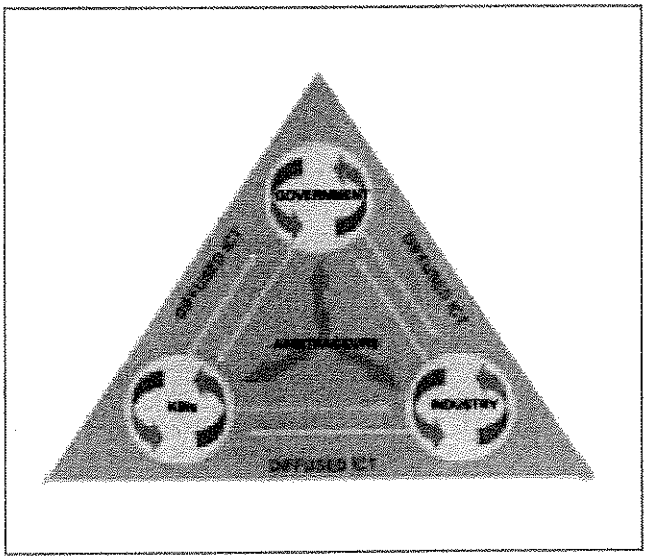
[3] For a recent review of the NSI concept, see (Lundvall., 2007).

From the evolution of the definitions provided, it is evident that there are certain recurring concepts, for example, organized (formal and informal) knowledge transfer, skills, interaction and learning. Institutions in the dual sense of organizations as well as the 'rules of the game' (North, 1991) are the cornerstones of this approach along with the transfer of tacit 'know-how' (to the extent possible) and codified knowledge.

Phrased differently, NSI consist of linkages (both formal and informal) and their intensity between institutions that facilitate intellectual flows and flows of knowledge resources (Buckley and Carter, 2004) in the economy. The fundamental enabling factor of these flows appears to be the extent of learning (taking into account the impact of geography and location) (Marshall, 1920).

However, given the definition that alludes to the 'envelope' of conforming policies, there are two points that are excluded from the traditional framing of NSI which we will include in our model, namely the effects of diffused information and communication technology (ICT) and arbitrageurs. Through the spread of digital information and ICTs a new mode of development has evolved (Perez, 1983; Freeman and Louça, 2001). Our conceptualization of ICT in NSI is not based solely on the concept of access, but 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 contextualize not just the quantity of hardware but also the corresponding performance in relation to all three NSI actors. Within the developing country context the three actors are perceived to hold relatively traditional and separate roles, with little or no overlap in function, i.e., "entrepreneurial academics, academic industrialists, and business strategy in government" (Ekztowitz, 2002, pp. 117). This is evidenced by the lack of bodies such as technology transfer or licensing offices within universities or venture capitalists. Therefore, access to the necessary financial and information resources would lead to the need for independent institutions, namely arbitrageurs. Figure 1 illustrates this concept.

Figure 1 Conceptualization of ICT in NSI



This paper addresses NSI because: a) they provide policy insights at a national level; b) the NSI model is well framed (Leydesdorf, 2001); and c) the variables are constrained within a national/geo-economic setting, therefore, there is formally no need to look into external variables with reference to actors' behaviour.

3. The Ghanaian context

As stated by the European Commission (2001) in Philpot et al. (2010, p.1) "Innovation is now the single most important engine of long-term competitiveness, growth and employment". This message is also echoed by Bordt et al. (2006) whose empirical work highlights the linkages between innovation and growth. Earl and Gault (2006) further elaborate on the concept by asserting that in order to successfully measure innovation, its outcomes and impacts, i.e., a systems approach should be applied. And, in this regard, there is a need to understand all components of the system and their relation to each other as "not only are actors and their activities important, but so are the linkages to other actors within the system (Earl and Gault, 2006, p. 2)".

To relate these concepts to the competitiveness of a nation, in this case, Ghana, we should also understand that "policy is a part of the system, and it has outcomes and impacts, just as a new technology or business process does" (Earl and Gault, 2006). From a developing country perspective it should be noted that there are good and some better ways to develop policy, but above all, it is important to "avoid copying the latest policy fashion" (Arocena and Sutz, 2000, p. 59). Thus, informed policy requires an understanding of the relevant actors within a system, their inter-relational dynamics and their individual requirements. The consequences of misinformed and incorrectly targeted policy is evidenced by the Canadian innovation system, when only certain human resource groups were targeted by programmes and policy which resulted in the creation of serious gaps (McDaniel, 2006).

Within the context of Ghana several unsuccessful attempts have been made over several years to promote science, technology and innovation for socio-economic development. However, in 2010 another attempt was made by the Government of Ghana and resulted in the formulation of the 'Science, Technology and Innovation (STI) System Development Programme of Ghana' and the document 'Policy Prescriptions for Technology and Innovation' [Ministry of Trade and Industry (MOTI)]. The 2010 programme differed from previous attempts as it was structured as an implementation plan for the overall STI policy developed in 2009. The short-term objective is to "restructure the entire science and technology machinery, infrastructure and programmes in order to make them more responsive to national needs and priorities in all sectors of the economy" (Ministry of Environment Science & Technology (MEST), 2010, p. 4). One of the activities aimed at achieving this objective is the establishment of an effective NSI for Ghana.

At this point it is worth mentioning that Ghana already has

a functioning NSI with reference to the presence of all three actors (government, industry and KBIs), and all have some degree of interaction. However, the question that needs to be posed is how effective these interactions are and how efficiently they function. This requires measuring NSI variables at the level of each actor.

The importance of understanding the positioning of the three actors' interactions, i.e., their exchange transactions and collaboration, is reiterated in the work of Leydesdorff and Etzkowitz (1998) who suggest that there are three forms of the 'neo evolutionary' Triple Helix (TH) Model that explain government, industry and KBIs' interactions. In TH-Type I, the three spheres of the actors are strongly institutionally defined, however, with relatively weak interactions across the defined boundaries, which occur through mediatory bodies (i.e., liaison, technology transfer and contract offices). TH-Type II differs in that the mechanisms of communication between the actors are strongly influenced by the market and technological innovations (Nelson and Winter, 1982) and the point of control is at the interfaces (Leydesdorff, 1997). Finally, in TH-Type III, the institutional spheres of the three actors as well as the performance of their traditional functions assume each others' roles. With the emergence of TH-Type III a complex network of organizational ties has developed, both formal and informal among the overlapping spheres. Hence, "universities take on entrepreneurial tasks such as marketing knowledge and creating companies, while firms develop an academic dimension, sharing knowledge among each other and training employees at ever higher skill levels" (Leydesdorff and Etzkowitz., 1998, p. 98).

The work of Porter, Sachs and McArthur (2002) provides an alternative means to illustrate the current stage of a country's development based on their 'three stage model'. First, the 'factor-driven stage' is represented by high levels of agricultural self-employment. Secondly, the 'efficiency-driven stage' is marked by increased production efficiency. And finally, the 'innovation-driven stage' is characterized by increased knowledge intensive activities. According to Sala-I-Martin et al. (2007), the first two stages of development are dominated by institutions whereas innovation has a greater impact on economic activity in stage three.

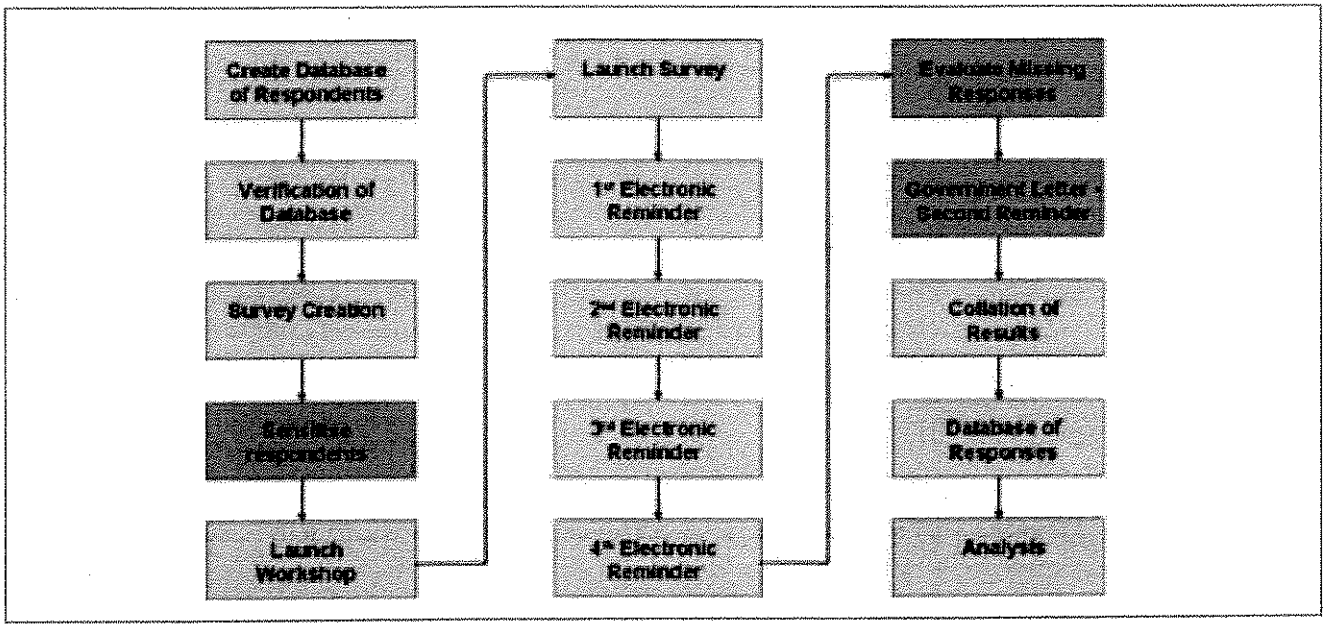
With this in mind, we would like to overlay both the three stage model and the Triple Helix model to justify the study of the systemic interactions of the actors within the NSI of Ghana. We postulate that suitable, well configured and well calibrated policies have the highest positive impact at the national level both in the innovation-driven stage and the Triple Helix Type III. Both of these focus on maximal interactions and knowledge intensive activities. The earlier stages in both models show the actors involved to have more of an independent role reliant on the basic subsistence economy. Transition from the first to the third stage in both models requires policy-driven changes at the institutional, market and actor level. Again, to gauge Ghana's current position and level of NSI assets as well as the relations required to make the transition to the 'innovation-driven stage' or to TH-Type III, clear measures and indicators are necessary.

To summarize, "at the most elementary level, evidence based policy making refers to the notion that policy intervention and direction are underpinned by an understanding of how things develop" (Gera et al., 2006, p. 58). One such means is through conducting an innovation survey which "although... under-exploited, they provide many opportunities for the development of new internationally comparable indicators" (Arundel et al., 2006, p. 183). The next section of the paper elaborates the proposed methodology, highlighting the ways in which it will provide substantial details about Ghana's NSI.

4. Methodology

This section discusses the steps involved in planning and executing the Ghana NSI survey, along with the problems associated with a study of this type, and the innovative meas-

Figure 2 . Graphical overview of the methodology used in conducting the Ghana NSI survey



ures taken to address these issues. Figure 2 above provides a graphical overview of the methodology used in conducting the Ghana NSI survey.

The first step in the survey process is the identification and creation of a comprehensive database of respondents. The target respondents chosen were derived from the three main NSI actor groups[4], according to the 'triple helix model' proposed by Leydesdorff and Etzkowitz (1996), and an extra intermediary body, namely:

First, the policy community (essentially the Government) is represented by officials working in the relevant division of public institutions who are directly or indirectly responsible for innovation. These include institutions such as the Ministry of Science and Technology, Economy, Finance, Trade, Education and Industry. Government funded research institutes are also included in this category.

Secondly, the knowledge community (KBIs) is represented by heads of university and innovation-related faculties/departments (economics, science, engineering and business) as well as heads of think tanks and research institutes. Privately funded research institutes are also considered in this category.

Thirdly, the industrial community is represented by the CEOs of firms in the medium- and high-technology manufacturing sector in accordance with the sectoral ISIC Rev. 3 classification.

Finally, the intermediary body selected was that of arbitrageurs, i.e., venture capitalists and knowledge brokers. This group of actors is not represented in the traditional TH model, but is of crucial importance as the innovation process requires internal and external knowledge which has led to the emergence of new business models and new types of companies. 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; and Baygan and Freudenberg, 2000). Their resource allocation role is based on the assessment of advantages in information asymmetries (Williamson, 1969, 1971, 1973).

For all selected actors full contact details were obtained: those of government representatives were provided by MEST and MOTI; the contact details of industry CEOs were retrieved from the online business directory Kompass, which was chosen on account of its comprehensive list of worldwide companies and the function allowing to find multiple e-mail addresses, and those for KBIs and arbitrageurs were obtained through desk research.

The next point of discussion is response rate. Low response rates are seen as problematic by the researcher as sampling error increases to the odds of samples that are too small to draw any meaningful conclusions from (Harzing, 2007). Overall response rates have been found to differ significantly, both across different professions and occupational groups as well as across countries. Evidence suggests that response rates by managerial staff are lower than those of non-managerial staff (Baruch, 1999). In a recent meta analysis, Cycyota and Harrison (2006) identified an overall top manager response rate of 32 per cent. In an international research context, these rates are, on average, likely to represent an upper boundary, however, steps were taken to maximize the response rate and will be addressed in more detail below.

The next step, one that requires a great deal of thought, is survey design. Generally, questionnaire length is considered an important predictor of response rate (e.g., Berdie, 1973; Tomaskovich-Devey, Leiter and Thompson, 1994). With respect to the Ghana NSI survey, the variables were developed based on a review of NSI literature by the UNIDO Statistical Research and Regional Analysis Unit, which initially consisted of 300 comprehensive variables. In order to ensure the highest possible response rate, the survey instrument was revised and the number of variables reduced to 138.

Empirical evidence supports the treatment of ordinal variables as conforming to interval scales (Labovitz, 1967, 1970, 1971). For this reason and for the purpose of clarity and ease, direction and strength of the response scales were carefully considered within the design process. Matell and Jacoby (1972) state that as the number of steps in a scale increases the number of respondents who use the midpoint decreases. However, the exclusion of a midpoint in a scale leads to a greater negative bias within the results (Garland, 1991). In light of this, the Ghana NSI survey incorporated a five-point Likert scale which utilized a midpoint, thus reducing the bias towards both extreme answers and towards false negatives.

The next step in the survey process is the choice of method for survey delivery of which numerous types exist within the literature, each with differing perspectives and assessments. From the list of mail, telephone, interactive voice response and internet, we chose the latter based on the following justifications: i) In terms of maximizing the use of the budget, internet surveys offer a much larger sample size than the conventional mail survey (Berrens et al., 2003); ii) The time dimension associated with conducting web-based surveys is much lower in comparison to other forms (Cobanoglu et al., 2001); iii) The quality of retrieved data is higher in terms of non-response and the ability to include conditionality in a discreet manner (Olsen, 2009); iv) Higher reliability of end responses is achieved due to the reduced need for data entry (Bartels et al., 2009; Ballantyne, 2004; Muffo et al., 2003). However, on the whole, there is need for caution when sampling using a web-based survey. In particular, careful attention needs to be paid to the level of computer access of the target population (Olsen, 2009). In the case of the Ghana NSI survey, the target population is a sub-population with very high internet access, even within the developing country context, and is therefore of less relevance.

[4] In 2009, the Ghanaian National Innovation Indicator Survey was conducted by the World Bank. The survey presented differs considerably from this earlier attempt in that the only actors surveyed were industry and KBIs. The governmental arm of the TH model was excluded (World Bank, 2009).

As previously noted, maximizing the response rate is crucial to achieve good survey results. Various strategies associated with the survey process exist to increase response rates. In general, it is advantageous to follow a multi-stage survey process that includes the circulation of an announcement letter and the distribution of reminders (Dillman, 2000). Announcement letters and reminders also have a secondary benefit, namely the creation of sponsorship. Harzing (2004) discusses the importance of sponsorship, particularly given the geographical and cultural distance between researchers and respondents. Generally, sponsorship can be provided by an international professional organization, participating organization, international committee of recommendations or at the level of the individual unit of analysis. Conversely, a negative aspect of sponsorship is the creation of the hawthorn effect (Zwane et al., 2010). As the survey will be conducted by UNIDO and MEST and MOTI, with the two ministries authoring the sensitization and reminder letters, a level of value may be attached to the survey by respondents, thus giving it an atypical degree of importance. In order to circumvent a bias of results, the amount of information relayed in both the invitation and the reminder letters with regard to the actual content of the survey will be minimal.

The next section looks at the expected outputs of the survey, the type of analysis to be conducted and the way in which the results can be used by the Government of Ghana.

5. Expected outputs

Given the typology of NSI variables measured by the survey, instrument analysis will be limited to three statistical analyses. These are frequency analysis (to provide an overview of the nature of the respondents with respect to NSI), cross tabulations (to provide comparisons and contrasts between respondents as actors in the NSI framework) and factor analysis (to indicate the underlying factors which significantly influence barriers to, and policy instruments for, innovation). With respect to frequency analysis and cross tabulation for the reporting of results and for the sake of parsimony, the five-point Likert scale will be collapsed into a dichotomy. The scale measures Very Familiar and Familiar and Neutral, Unfamiliar and Very Unfamiliar reclassified as Familiar and Unfamiliar, respectively. Neutral is placed on the negative side of the dichotomy in the assumption that the respondents are actors in the NSI, irrespective of the state of its development and are assumed to be knowledgeable; hence, neutral does not represent a positive result. This position reduces the tendency to overstate the state of development of the NSI, notwithstanding the argument of potential bias (Bachman and O'Malley, 1984; Chen, Lee & Stevenson, 1995)

The utilization of factor analysis as an analytical method will enable the identification of a relatively small number of factors or underlying dimensions that can be used to represent relationships within the variable set (Stewart, 1981). The factors deduced are a representation of the underlying structure that is responsible for the variation of variables in the data and thus the population (Kim Jae-On and Mueller, 1978). Phrased differently, the factors obtained will infer the commonalities and divergence of the underlying perceptions of NSI actors towards the present Ghanaian NSI.

To complement the survey's primary statistical outputs, a secondary level of outputs on the enhancement and institutionalization of the NSI concept amongst the NSI actors will be aimed at as well. To this end, outputs and their impacts will include: i) Co-authored academic publications—enhancing collaborative activities, exchange of ideas and codification of knowledge; ii) Policy briefs and papers—provision of guidelines for the creation of and spatial and temporal management of incentives; iii) Policy seminars and workshops—exchange of ideas and transfer of tacit knowledge; iv) Establishment of cross institutional networks—establishment of the mechanisms for exchange of tacit and codified knowledge; v) establishing and developing the capacity and capability for the repetition of the survey—institutionalization of NSI and development of longitudinal measurement and monitoring capacity; and forging collaborations with international partners (Vienna University of Technology)—expansion of institutional collaborative networks dedicated to the study of NSI.

6. Conclusions

To summarize the core concepts presented in this paper it should first be noted that knowledge production and transfer and increased diversification are a prerequisite for competitiveness and economic advancement.

To this end, the establishment of the specific organizational structures and mechanisms for the aforementioned knowledge creation and transfer is a challenge, particularly when visualized from a national systemic context. Traditional models for the illumination of this concept have often been oversimplified, with key actors being excluded, particularly in the developing country context.

With this in mind, advancement in terms of knowledge creation, dissemination and diversification requires focused evidence based policy, which in turn requires a clear mapping of resources, an understanding of the perceptions of key actors as well as their interactions. Measurement and mapping at the national level is of particular importance as it enables policymakers to effectively direct what little resources they have.

The survey methodology outlined in the paper is both innovative and dynamic, however, to maximize its potential impact on the crafting of policy there is a need for further study and replication to obtain a longitudinal perspective.

References

Allen, P. M. (2000). Knowledge, ignorance, and learning. *Emergence*, vol. 2, No. 4, pp. 78–103.

Antonelli, C (1999). The evolution of the industrial organisation of production. *Cambridge Journal of Economics*, vol. 23, No. 2, pp. 243–260.

Archibugi, D., and S. Iammarino (1999). The policy implications of the globalisation of innovation, *Research Policy*, vol. 28, No. 2-3, pp. 317–336.
Arocena, R., and J. Sutz (2000). Looking and national systems of innovation from the South. *Industry and Innovation*, vol. 7, No. 1, pp. 55–75.

Arundel, A., A. Colecchia, and A. Wyckoff (2006). The role of benchmarks and targets in Canadian innovation policy. In *National Innovation Indicators and Policy*, L. Earl and F. Gault, eds. Northampton: Edward Elgar Publishing.

Asheim, B. T., and L. Coenen (2004). The role of regional innovation systems in a globalizing economy: Comparing knowledge bases and institutional frameworks of Nordic clusters. Paper no. 2005/03. Lund: Centre for Innovation, Research and Competence in the Learning Economy (CIRCLE).

Bachman, J. G., and P. M. O'Malley (1984). Yea-saying, nay-saying, and going to extremes: Black-White differences in response styles. *Public Opinion Quarterly*, vol. 48, pp. 491–509.

Ballantyne, C. (2004). Online or on paper: An examination of the differences in response and respondents to a survey administered in two modes. Paper presented at the Australasian Evaluation Society. International Conference, Adelaide, October.

Bartels, F. (2005). Determinants of national innovations system: Policy implications for developing countries. Paper presented at the 14th International Conference on Management of Technology, Vienna, May.

Bartels, F., H. Voss, C. Bachtrog, and S. Lederer (2008). Determinants of National Innovation Systems: Policy Implications for developing countries. *Innovation Management Policy and Practice* - In Press.

Bartels, F. L., R. Koria, and S. Carneiro (2009). National systems of innovation in selected emerging market economies: An examination of actors, Interactions and Constraints, EAMSA Conference, Lausanne, Switzerland, October 22-24.

Bartels, F. L., and S. Lederer (2009), Changing patterns in industrial performance – A UNIDO competitive industrial performance perspective: Implications for industrial development. Working Papers, No. 05/2009, Vienna: Research and Statistics Branch, UNIDO.

Baruch, Y. (1999). Response rate in academic studies – A comparative analysis. *Human Relations*, vol. 52, No. 4, pp. 421–38.

Baygan, G., and M. Freudenberg (2000). The internationalisation of venture capital activity in OECD countries: Implications for measurement and policy. OECD Science, Technology and Industry Working Papers 2000/7, Paris: OECD.

Berdie, D. R. (1973). Questionnaire length and response rate. *Journal of Applied Psychology,* Vol.58, No. 2, pp. 278–280.

Berrens ,R. P., and others (2003). The advent of internet surveys for political research: A comparison of telephone and internet samples. *Political Analysis*, vol. 11, No. 1, pp. 1–22.
Bjørnskov, C., and G. T. Svendsen (2002). Why does the northern light shine so brightly? Decentralisation, social capital and the economy, Working Paper, No. 15, Aarhus: Aarhus School of Business.

Blanc, H. and C. Sierra (1999). The internationalisation of R&D by multinationals: a trade-off between external and internal proximity, *Cambridge Journal of Economics*, vol. 23, No. 2, pp. 187–206.

Bordt., M., and others (2006). The role of benchmarks and targets in Canadian innovation policy. In *National Innovation Indicators and Policy*, L. Earl and F. Gault, eds. Northampton: Edward Elgar Publishing.

Braadland, T. E., and E. Anders (2002). Innovation in Norwegian industries – Testing a new taxonomy. STEP Report Series, No. 200206, Oslo: The STEP Group.

Buckley, P. J., and M. J. Carter (2004). A formal analysis of knowledge combination in multinational enterprises. *Journal of International Business Studies*, vol. 35, No. 5, pp. 371–384.
Carlsson, B. (2006). Internationalization of innovation systems: A survey of literature. *Research Policy*, vol. 35, No. 1, pp. 56–67.

Chen, C., S-Y Lee, and H. W. Stevenson (1995). Response style and cross-cultural comparisons of rating scales among East Asian and North American students. *Psychological Science*, vol. 6, No. 3, pp. 170–175.

Cobanoglu C., B. Warde, and P. J. Moreo (2001). A comparison of mail, fax and web-based survey methods. *International Journal of Market Research*, vol. 43, No. 4, pp. 441–452.

Cohendet, P., and others (1999). Knowledge coordination, competence creation and integrated networks in globalised firms. *Cambridge Journal Economy*, vol. 23, No. 2, pp. 225–241.

Cycyota, C. S., and D. A. Harrison (2006). What (not) to expect when surveying executives. *Organizational Research Methods*, vol. 9, No. 2, pp.133–60.

Dillman, D. A. (2000). *Mail and Internet Surveys: The Tailored Designed Method*, 2nd Edition. New York: Wiley.

Dosi, G., and others (1988). *Technical Change and Economic Theory*. London: Pinter.

Dunning, J. H. (1997). Technology and the changing boundaries of firms and governments. In *Industrial Competitiveness and the Global Economy*. Paris: OECD.

Earl, L., and F. Gault (2006). The role of benchmarks and targets in Canadian innovation policy. In *National Innovation Indicators and Policy*, L. Earl and F. Gault, eds. Northampton: Edward Elgar Publishing.

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

Etzkowitz, H. (2002). Incubation of incubators: innovation as a triple helix of university-industry-government networks. Science and Public Policy, vol. 29, No. 2, pp.115-128

European Commission (2001). Building an Innovative Economy in Europe. A Review of 12 Studies of Innovation Policy and Practice in Today's Europe, EUR 17043, Brussels.

European Research Council Expert Group (2003). A Cornerstone in The European Research Area. (Conference Report), Ministry of Science, Technology and Innovation, Copenhagen, Denmark, December 15, Brussels, European Commission. European Life Sciences Forum (ELSF) Available from http://www.elsf.org/elsfercpubs/elsfercpubc8.pdf

Fischer, M., J. Revilla-Diaz, and F. Snickars (2001). *Metropolitan Innovation System: Theory and Evidence from Three Metropolitan Regions in Europe,* New York: Springer.

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

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

Garland, R. (1991). The mid-point on a rating scale: Is it desirable? Research Note 3, Marketing Bulletin, vol. 2, pp. 66–70.
Gera, S., R. Roy, and T. Songsakul (2006). The role of benchmarks and targets in Canadian innovation policy. In *National Innovation Indicators and Policy*, L. Earl and F. Gault, eds. Northampton: Edward Elgar Publishing.

Hargadon, A. B. (1998). Firms as knowledge brokers: Lessons in pursuing continuous innovation. *California Management Review*, vol. 40, No. 3 (Spring).

Harzing, A. W. (2007). *Journal Quality List*, 28th Edition. Available from http://www.harzing.com

Harzing, A. W. (2004). The use of English questionnaires in cross-national research. *The International Journal of Cross Cultural Management* – under review.

Hilbert, M., P. López, and C. Vásquez (2010). Information societies or "ICT equipment societies?" Measuring the digital information-processing capacity of a society in bits and bytes. *The Information Society,* vol. 26, No. 3, pp. 157–178.
Karlan, D. S., and others (2010). Being surveyed can change later behavior and related parameter estimates. *PNAS*, vol.108, No. 5, pp. 1821–1826.

Kim J-O., and C. Mueller (1978). Factor analysis: Statistical methods and practical issues, Quantitative Applications in Social Sciences Series, No. 14, Thousand Oaks: Sage Publications.
Labovitz, S. (1967). Some observations on measurement and statistics. *Social Forces*, vol. 46, No. 2 (December), pp. 151–160.

Labovitz, S. (1970). The assignment of numbers to rank order categories. *American Sociological Review*, vol. 35, No. 2, pp. 515–524.

Labovitz, S. (1971). In defence of assigning numbers to ranks. *American Sociological Review*, vol. 36, No. 4, pp. 521–22.
Leydersdorff, L. and H. Etkowitz (1996). Emergence of a triple helix university-industry-government relations. *Science and Public Policy*, vol. 23, No. 5, pp. 279–286.

Leydesdorff, L. and H. Etzkowitz (1998). The triple helix as a model for innovation studies (Conference Report). *Science and Public Policy*, vol. 25, No. 3, pp.195–203.

Leydesdorff, L. (2001). Knowledge-based innovation systems and the model of a triple helix of university-industry-government relations. Paper presented at the Conference on New Economic Windows: Paradigms for the New Millennium. Sacerno, September.

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

Leydesdorff, L. (1997). The new communication regime of university-industry-government relations. In Etzkowitz and Leydesdorff ed. Universities and the Global Knowledge Economy: A Triple Helix of University-Industry-Government Relations: London ; New York: Pinter, pp.106-117.

List, F. (1841). Das nationale System der politischen Ökonomie. Basel: Kyklos, translated and published in *The National System of Political Economy*, Longmans, ed. London: Green and Co.

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 Edition. London: Macmillan and Company Ltd.

Matell, M. S. and J. Jacoby (1972). Is there an optimal number of alternatives for Likert scale items? Effects of testing time and scale properties. *Journal of Applied Psychology*, vol. 56, No. 6, pp. 506–509.

McDaniel., S. A. (2006). The role of benchmarks and targets in Canadian innovation policy. In *National Innovation Indicators and Policy*, L Earland F. Gault, ed. Northampton: Edward Elgar Publishing.

Metcalfe. S. (1995). The economic foundations of technology policy: Equilibrium and evolutionary perspectives. In P.

Stoneman. Handbook of the economics of innovation and technological change. Oxford, Blackwell: 409-512.

Ministry of Environment, Science & Technology (MEST) (2010). Science, technology, & innovation (STI) for the development of Ghana. STI Development Programme for Driving Ghana into a Middle Income Status (STIDEP) 2011–2015.

Muffo, J. M., A. Sinclair, and V. Robson (2003). A comparison of web versus paper alumni surveys. Paper presented at the Annual Forum of the Association for Institutional Research, Tampa, U.S.A. May 17–21.

Munk, K. B., and C. Vintergaard (2004). Venture capitalists in systems of innovation. MPP Working Paper No. 1/2004, Deptartment of Management, Politics and Philosophy, Copenhagen: Copenhagen Business School.

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

Nelson, R. R. and Rosenberg, N. (1993). Technical innovation and national systems. In *National Systems of Innovation a Comparative Study*. R. R. Nelson, ed. Oxford: Oxford University Press.

Niosi, J., and others (1993). National systems of innovation. In *Search of a Workable Concept. Technology in Society*, vol. 15, pp. 207–227.

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

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

Olsen, S. B. (2009). Choosing between internet and mail survey modes for choice experiment surveys considering non-market goods. Environmental and Resource Economics, vol. 44, No. 4, pp. 591–610.

Oyelaran-Oyeyinka, B. (2005). Partnerships for Building Science and Technology Capacity in Africa. In: Africa-Canada-UK Exploration: Building Science and Technology Capacity with African Partners. London, UK, 30 January - 1 February
Patel, P., and K. Pavitt (1994). National innovation systems: Why they are important, and how they might be measured and compared. *Economics of Innovation and New Technology*, vol. 3, No. 1, pp. 77–95.

Pavitt, K. (1984). Sectorial patterns of technical change: Towards a taxonomy and a theory. *Research Policy*, vol. 13, No. 6, pp. 343–373.

Perez, C. (1983). Structural change and assimilation of new technologies in the economic and social systems. *Futures*, vol. 15, No. 5, pp. 357–75.

Philpot, K., and others (2010). The entrepreneurial university: Examining the underlying academic tensions. *Technovation* (2011), doi:10.1016/j.technovation.2010.12.003
Porter, M., J. Sachs, and J. McArthur (2002). Executive Summary: Competitiveness and stages of economic development. In *The Global Competitiveness Report 2001–2002*, M. Porter,

J. Sachs, P. K. Cornelius, J. McArthur, and K. Schwab, eds. New York: Oxford University Press.

Sala-I-Martin, X., and others (2007). The Global Competitiveness Index: Measuring the productive potential of nations. In *The Global Competitiveness Report 2007–2008*, M. Porter, K. Schwab, and X. Sala-I-Martin, eds. Hampshire: Palgrave Macmillan.

Schoser, C. (1999). The institutions defining national systems of innovation: A new taxonomy to analyse the impact of globalization. Paper presented at the Annual Conference of the European Association of Evolutionary Political Economy,Prague, Czech Republic, November 4-7

Stewart, D.W. (1981). The application and missaplication of factor analysis in marketing research. *Journal of Marketing Research*, vol. 18, No. 1, pp. 51–62.

Tomaskovic-Devey, D., J. Leiter, and S. Thompson (1994). Organisational survey non response. *Administrative Science Quarterly*, vol. 39, No. 3, pp. 439–57.

Williamson, O. E. (1973). Markets and hierarchies: Some elementary considerations. *American Economic Review*, American Economic Association, vol. 63, No. 2, pp. 316–25.
Williamson, O. E. (1971). The vertical integration of production: Market failure considerations. *American Economic Review*, American Economic Association, vol. 61, No. 2, pp. 112–23.

Williamson, O. E. (1969). Allocative efficiency and the limits of antitrust. *American Economic Review*, American Economic Association, vol. 59, No. 2, pp. 105–18.

Zook, M. A. (2003). The knowledge brokers: Venture capitalists, tacit knowledge and regional development. Paper presented at DRUID Summer Conference 2003 on Creating and Sharing, Sharing and Transfering Knowledge. The Role of Geography, Institutions and Organizations. Copenhagen, Denmark, June 12-14

Zwane, A. P., Zinman, J., Dusene, E.V., Pariente, W., Null, C., Miguel, E., Kremer, M., Karlan, D. S., Hornbeck, R., Giné, X., Duflo, E., Devoto, F., Crepon, B., & Banerjee, A. (Being surveyed can change later behavior and related parameter estimates. PNAS, vol. 108, No. 5, pp. 1821-1826.