“Role of higher education institutions in private sector human capital development within a national system of innovation”

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Role of higher education institutions in private sector human capital development within a National System of Innovation

Abstract

This research examines the role of higher education institutions (HEIs) in private sector human capital development (HCD) within the South African National System of Innovation (NSI). The pragmatic research design adopted provides the basis for undertaking mixed-method research, namely, quantitative followed by qualitative, supplemented by secondary documents. The methodological data analysis triangulation technique facilitated achievement of a 'whole that was greater than the sum of its parts'. The following questions were asked: 'What is the role of HEIs in private sector HCD within the NSI?' and 'How can HCD and other components of knowledge infrastructure be strengthened within the NSI?

The findings identified the HEIs as an important source of HCD within the NSI. However, they also showed that HEIs face considerable constraints that hinder HCD, including human resource capacity gaps, and lack of infrastructure and funding. The findings also identified collaboration between HEIs and the private sector as an important avenue for HCD. It is recommended that improving HCD should be high on the 'triple-helix' policy agenda. Also, the importance of capacity building in relevant skills sets is emphasized. An adequate knowledge infrastructure is a crucial condition for a well-functioning NSI, and strategies to strengthen HCD in South Africa should, therefore, be implemented as a matter of urgency.

Keywords: human capital development, higher education institutions, National System of Innovation, sustainable development.
JEL Classification: I23.

Introduction

This research reviews the framework conditions of South African higher education institutions' (HEIs') human capital development (HCD) at both national and local (within departments and ministries) level. It examines South Africa's National System of Innovation (NSI) performance of science, technology and innovation, with particular reference to HCD towards transition into the anticipated knowledge-based economy. This knowledge-based economy is highlighted by the South African Department of Science and Technology (DST)'s ten-year innovation plan (TYIP) (2008-2018) (DST, 2008) for achieving national development priorities.

Focus questions. This study asked the following two research questions:

1. What is the role of HEIs in private sector HCD within the South African NSI?; and
2. How can HCD and other components of knowledge infrastructure be strengthened within the South African NSI?

Problem statement. South Africa is an emerging economy where significant progress has been made over the past 15 years. However, significant HCD challenges need to be addressed within the NSI. According to the Organization for Economic Co-operation and Development (OECD) (OECD, 2007) and the South African Department of Science and Technology (DST) Ministerial Review Committee (2012), there is much that should be done to optimize the functioning of the South African NSI. The argument is that research within the NSI, especially at national level, is valuable for developing appropriate policies for shaping and predicting NSI actors' behavior (Liu and White, 2001, p. 1093; Von Hippel and Jin, 2009, pp. 19-21). A seminar paper presented by Lorenz (2014) showed that social capital, defined as networks and patterns of social interaction, increases the likelihood that firms innovate in the NSI. Further, it shows that the benefits of R&D expenditures and employee training for the firm's innovation performance are moderated by the level of national social capital and for the HCD. Therefore, it is important to examine the construct of HCD within the NSI.

In 2008, the DST drafted its TYIP (2008-2018) aimed at driving South Africa's transformation towards a knowledge-based economy, from a historically resource-based economy, using various output indicators. During the Institute for Economic Research on Innovation (IERI) Seminar, Kriger (2015) seeks to contextualize the historical challenges of more than a century of HEIs and research in South Africa by placing these into the associated, broader and formative socio-political developments since 1997. Therefore in addressing the challenges facing the HEIs in South Africa, the realization of the proposed TYIP of 2008, the NSI perspective will primarily be concerned with the flow and impact of the knowledge ecology on economics. However, the DST is unlikely to achieve some of the outlined output targets (Table 1) for a number of reasons, the main one being the lack of alignment within government structures.

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Table 1. HCD actions and outcomes desired of the HEIs

By 2018 South Africa will have:
♦ 210 research chairs at universities and research institutions across the country by 2010 and 500 by 2018 (58 were in place in 2006).
♦ About 6000 PhDs produced per year in all science, engineering and technology disciplines by 2018.
♦ About 3000 science, engineering and technology PhDs/doctorates produced per year by 2018.
♦ An optimal ratio of technicians and researchers.
♦ A 2.5% global share of research publications (2006: 0.5%).
♦ 2100 Patent Cooperation Treaty international applications originating from South Africa (2004, p. 418).
♦ About 24 000 patent applications at the South African Patent Office (2002, p. 4721).

Source: DST (2008, p. 9).

In the TYIP's proposed knowledge economy, achieving sustainable development in the NSI will depend on the depth and width of South Africa's reservoir of human capital to support both public and private enterprises.

The 2007 OECD Country Review indicates that uncertainty can be delineated to the success in SA, due to: (1) high dropout rates from the school system for economic and social reasons, such as poverty and HIV/AIDS; (2) relatively low numbers of students moving into scientific and technological subjects in further education and training; and (3) a considerable dropout rate, especially among the scientific and technological fields in higher education.

Among those who graduate with first degrees in scientific and technological subjects, a large proportion moves directly into employment rather than going on to postgraduate training. High dropout rates remain the case at postgraduate level, and a high number of those who graduate at Master's or PhD level move directly into employment outside research and development because of more attractive prospects, rather than proceeding from a Master's degree to doctoral training or postdoctoral research (OECD, 2007, pp. 151-152). Harvey (2000, p. 3) points out that a causal link implies that HEIs "should be able to provide graduates with some sort of package of attributes that meshes with what an employer is looking for". Furthermore, the South African Department of Education's National Plan for Higher Education (2001, p. 15) provides "the strategic framework for re-engineering the higher education system for the 21st century", posing the question whether HEIs are, indeed, geared towards addressing the human resources skill shortages facing South Africa.

1. Literature review

1.1. Defining human capital development (HCD). The OECD (1998, p. 9) defined human capital as "the knowledge, skills, competences and other attributes embodied in individuals that are relevant to economic activity". The fourth of the five key principles in the DST's TYIP (2008, p. 5) states: "Sustainable capacity: the R&D scale-up must be consistent for the system to have the appropriate absorptive capacity, with each element (for example, skills, capital spend) relying on others for the system to work". An explicit and proactive human capital policy is an important key issue for the knowledge ecology (Foray, 2010, p. 103). The proposed shift to a knowledge economy stated in the TYIP (2008) will require a planned, concerted, well-resourced and sustained human resource program of action by all the relevant NSI policy-makers and performers.

The South African government has embarked on the New Growth Path (NGP) Framework by EDD (2010), which centers on a massive investment in five key infrastructure areas, namely: (1) energy; (2) transport; (3) communication; (4) water; and (5) housing to create jobs in construction, operation and maintenance of infrastructure, as a critical driver of dealing with the sluggish economic growth, poverty and joblessness. In this research context, an effective NSI framework, which nurtures research, research commercialization and innovation, will be pivotal in realizing the proposed NGP framework. A discrepancy exists between the intentions of the New Growth Path (NGP) vision 2030 by EDD (2010) the TYIP of 2008 HCD actions in Table 1 above and the Twelve Outcomes of government and the associated Delivery Agreements. The South African HCD system is locked into sets of inter-dependent 'pipeline jams' with piecemeal interventions having so far served only to make the supposedly 'fatigued' system more refractory to positive change (SA DST Ministerial Review Committee, 2012, p. 144).

1.2. Human capital development (HCD) in South Africa. South African HEIs in varying degrees combine the functions of education, research, entrepreneurship and community engagement (Gordon and Craig, 2001; Mowery and Sampat, 2007). Therefore; a sound knowledge base is important for innovation (Sriniνasand Sutz, 2008). Similarly, in an increasingly knowledge-based economy, Doutriaux and Sorondo (2005, p. 2) state that investment in knowledge and output of research offer valuable dividends because:

Knowledge and innovation are increasingly recognized as sources of global competitiveness and economic well-being. Research on systems of innovation has shown that a country's capability to introduce new and innovative products and services that contribute to its wealth is related to its research activities, to its proportion of scientists and

engineers, to its policies and programs supportive of research and its commercialization.

The key to the successful transfer of new ideas is the "establishment of a knowledge network on innovation" (Galimberti, 2005, p. 11). This research views human capital for innovation as a focal point in any knowledge ecology policy, sharing similar views to the OECD (1998, p. 11) and Foray (2010, p. 103). In addition, scientific and technological knowledge is an essential element of innovation, and the foundation for economic development (OECD, 2003, p. 9). The OECD (1998, p. 12) notes that "scientific knowledge can play an essential role for innovation and economic development". Furthermore, generation, exploitation and diffusion of knowledge have been fundamental to the economic development and well-being of nations or regions (Lember, Kalvet and Kattel, 2014, p. 84).

This article adopts the human capital theory, which serves as a guide for reviewing the South African human resources and HCD framework conditions. Human capital theory rests on the nation's human capital for the advancement of the population (Schultz, 1961). The assumption is that education contributes directly to growth in the national income of societies, and is not merely a form of consumption (Schultz, 1961, pp. 640-641). A further assumption is that improved technology will lead to greater production and that skills for the use of technology can be acquired through formal education.

The development intent of South Africa's science, technology and innovation policies was declared in the White Paper on Science and Technology (DST, 1996), which set a precedent for a system for creation and application of knowledge. A case for the establishment and step-wise roll-out of "provision of infrastructure" (DST, 1996, p. 19) roadmap exists in South Africa, with strong knowledge institutions being the best indication of a sound infrastructure in the South African NSI.

1.3. Higher education institutions (HEIs) within the NSI. The NSI constitutes a multitude of porous sub-systems that are geographically dispersed and sectoral or institutional in nature, each of which may be promoted or hindered in its own right, directly or indirectly. The HEIs are a significant NSI actor within the 'triple-helix' model that includes the government and the productive sector, namely, the private formal sector and the informal sector (agricultural and small/medium enterprises). The benefits of triple-helix interaction in this research context are many, as the model allows for combinatory innovations to take place among the three interdependent main actors, and reorganization of the spiral as the South African NSI evolves. Etzkowitz, Dzisah, Ranga and Zhou (2007) used the helix metaphor to demonstrate a triple-spiral policy network where industry, academia and the state interact in an evolutionary fashion, allowing for new, innovative recombination. The triple-helix model of HEIs-industry-government framework provides this study with an avenue for examining the role of HEIs' HCD within the NSI. Within the NSI the HEIs are important generators of new ideas and promoters of innovation (Etzkowitz, Dzisah, Ranga and Zhou, 2007, p. 11).

This research defines the NSI according to the DST (2002, p. 22) as a "set of functioning institutions, organizations and policies which interact constructively in the pursuit of a common set of social and economic goals and objectives, and which use the introduction of innovations as the key promoter of change". Furthermore, the Department of Education and Department of Labor National Plan for Higher Education (2001) poses the question of whether HEIs are, indeed, geared towards addressing the human resource skills shortages facing South Africa. Brennan, Kogan and Teichler (1999, p. 15) state that the HEIs are less equipped "to steer these processes systematically than (they are) to shape the cognitive domain of academic learning".

According to the New Growth Path Framework of the South African Department of Economic Development (EDD) (EDD, 2010, p. 278), South Africa produces 28 PhD graduates per million members of the population per year, which is low by international standards. The New Growth Path (EDD, 2010, p. 278) targets 100 PhD graduates per million per year by 2030, which translates into more than 5000 graduates per year – against the figure of 1420 in 2010; the TYIP targets about 6000 PhDs per year in all science, engineering and technology disciplines by 2018. The New Growth Path (EDD, 2010, p. 278) further states that "if South Africa is to be a leading innovator, most of these doctorates should be in science, engineering, technology and mathematics". Failure of human resource provision is the key weakness of the NSI, which represents a joint failure across government for which no short-term solution is in operation (DST Ministerial Review Committee, 2012, p. 78).

In management of the knowledge infrastructure two guiding interventions by the South African government have been utilized to addressed backlogs and planned (non-cyber) infrastructure for the future, namely: (1) the National Research and Technology Infrastructure Strategy developed by the National Research Foundation in 2004; and (2) a study commissioned by the National Advisory Council on Innovation in 2006, which is in current use as a baseline for funding research infrastructure applications.

With respect to cyber-infrastructure in South Africa, a significant public investment in high-performance computing, fast broadband networks and very large database storage has been made available in the past decade, mostly through the Meraka Institute at the Council for Scientific and Industrial Research. Although Pinto and Slevin (1988, pp. 483-514) state that "knowledge management is not about technology", in policy making information and communication technologies it can be utilized to replicate historical processes and data management, for storing emerging knowledge, best practice, and standards to avoid fossilization.

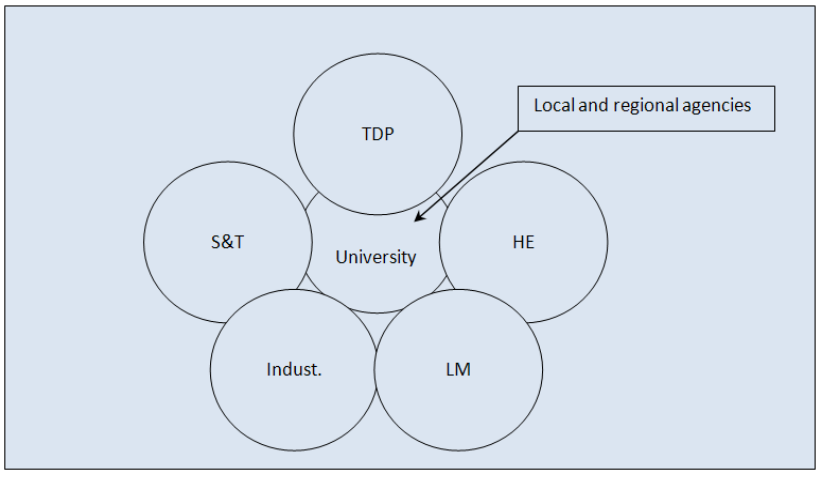
1.4. The landscape of HEIs in South Africa. This research maintains both an 'outward' and an 'inward' dimension in examining the role of HEIs. Inwardly, the research reviews the HEI landscape in South Africa, while outwardly the central issue is identification of specific mechanisms for constructive collaboration between the HEIs and other NSI actors. This research recognizes the HEIs as essential contributors to sustainable development through the production of knowledge, skills and innovations needed to drive the regional and national economies. In this research context the HEIs play a pivotal role in research and incubation of scientific and technological innovations that promote real and sustained economic and social development. The functioning of South Africa's NSI is dependent on the interface between the human capital production pathways and innovation-driven SD.

However, given limited funding and significant financing challenges, many African HEIs are under increasing pressure to demonstrate their social and economic relevance (Lundvall, 2007). Dialogue on the triple helix, with reference to HEI-industry linkages, is increasingly coming to the fore in HEI policy in Africa.

In South Africa the Higher Education Act No. 101 of 1997, amended in 1999, 2000 and 2001, and the White Paper (Department of Education, 1997) provided the overall regulatory and policy framework for HEIs, placing overall control of the HEIs in the hands of the National Advisory Council on Innovation. South African HEIs enjoy autonomy in the form of financial planning, staff policy, hiring/firing and wages, student selection and course content and accountability in the form of evaluation mechanisms and funding rules.

While the number of HEIs has been reduced from 36 to 23, largely by merging technikons (technical colleges or polytechnics), the higher education sector as a whole has expanded dramatically since 1994, with the number of students rising from 473 000 in 1993 to 718 000 by 2003. Dropout rates appear to have been rising in line with the increasing proportion of students from disadvantaged backgrounds in the higher education system. By restructuring the HEIs system, the White Paper (Department of Education, 1997, p. 13) aimed to "Deliver the requisite research, the highly trained people and the knowledge to equip a developing society with the capacity to address national needs and to participate in a rapidly changing and competitive global context."

Figure 1 indicates national policies impacting on university/regional relations. At national level the main policies impacting on HEI/regional relations include those relating to: (1) science and technology; (2) territorial development; (3) higher education; (4) the labor market; and (5) industrial policy.



Key: S&T Science and technology;
TDP Territorial development;
HE Higher education;
LM Labor market.

Fig. 1. National policies impacting on university/regional relations

1.5. Higher education institutions – private sector partnership. According to the Centre for Development and Enterprise (2000, p. 4), "South Africa's universities have by and large not adapted to the economic needs facing South Africa, and are not sufficiently responsive to business's needs". In summary, according to Stumpf (2011, pp. 3-4), the HEIs are characterized by low graduation rates and high dropout rates, which has negative consequences in transitioning into the knowledge economy. During the past decade strengthening universities of technology has proved difficult, as has increasing the share of student enrolments. Significant barriers to expansion of the postdoctoral sector continue to exist in the HEIs. Much-improved functionality in HEIs simply has to be achieved in order to increase access and raise participation and completion rates (Stumpf, 2011, pp. 3-4). This research posits that a concerted, innovative approach must be adopted to allow the HEIs to overcome the constraints that still shackle them despite the structural interventions during the last decade.

2. Methodology

2.1. Mixed-method design. The research design examined the HEIs' HCD performance, highlighting specific collaborations within the NSI. This research utilized a mixed-method design, which is well supported by researchers, such as Ivankova, Creswell and Plano-Clark (2007), and Creswell and Plano-Clark (2011). A research design is a plan or proposal to conduct research, involving the intersection of philosophy, strategies of inquiry and specific methods (Creswell and Plano-Clark, 2011, p. 3). In this research context, the research design describes the procedures for conducting the research, including when, from whom, under what conditions the data will be obtained (McMillan & Schumacher, 2011, p. 110).

According to Kane and O'Reilly-de Brun (2001), a problem or an issue that a researcher is probing determines the research design as well as the research methods and techniques to be used. The ontological position has been adopted which is contained within enquiry of social phenomena of sustainable development in South Africa through research and the continual process of the NSI actors to drive innovation. Ontology in this research context has been used to examine the nature of the NSI and the relations involved. The epistemology of this research is located within an interpretive paradigm (Grix, 2002, pp. 177-180), whose central endeavor is to explore the NSI actors interactions.

Using basic, analytical (strategic) and experimental research classification, this research can be classified as strategic because the purpose is to provide recommendations for strengthening NSI actors' partnerships and the HCD.

The research adopted a pragmatic approach because mixed methods designs can provide pragmatic advantages when exploring complex research questions. The pragmatic approach has been selected as it sheds light on how research approaches can be mixed fruitfully to offer the best opportunities for addressing research questions. Pragmatism also provided a philosophical basis for a mixed method research as it is not committed to any one system of philosophy and reality and the philosophy does not see the world as an absolute unity (Morgan, 2007). Therefore, pragmatism provided the theoretical basis for conducting this mixed-method research.

2.2. Sample size. In this research, the relevant population was made up of the HEIs, which consists of twenty three universities classified into three groups: eleven traditional/conventional research oriented universities offering discipline-based degrees, six universities of technology focusing on career-orientated and professional programs, six universities of technology and six comprehensive (or dual) universities combining both roles. The Frascati Manual (OECD, 2002b, p. 77) describes the higher education sector as comprising "all universities, colleges of technology and other institutions of post-secondary education, whatever their source of finance or legal status. It also includes all research institutes, experimental stations and clinics operating under the direct control of or administered by or associated with higher education institutions". The questionnaire targeted the Vice Chancellors (VCs) of Research, Deans of Research and Directors of Innovation Centres.

2.3. Research instruments. Quantitative data were collected by means of a survey questionnaire, which was pilot tested beforehand (Appendix 1) which was administered to a purposeful sample of twelve Heads of Research. Ethical issues were considered during the entire research process which included obtaining ethical clearance, confidentiality of data collection and data presentation. The qualitative data were collected by means of semi-structured one-to-one interviews with purposefully selected Heads of Research (Appendix 2). All interviews took place at a time agreed upon between the researcher and Heads of Research institutions. The set of predetermined questions guided the open-ended interviews

Both the questionnaire and interview data was analyzed according to a combination of the seven phases of the mixed-method analysis process proposed by Onwuegbuzie and Teddlie (2003, pp. 351-356).

The questionnaire captured HEIs activities on the construct of SD in South Africa through research in the NSI. It consisted of five sections:

1. The participating institution's demographic profile.
2. The role of research and SD within the HEIs.
3. Measuring effectiveness (barriers and challenges) of research commercialization within the HEIs.
4. Exploring the nature of interactions between the HEIs and other NSI actors.
5. Establishing the nature of government support, funding and incentives to the HEIs.

This research commenced with an open-ended questionnaire, followed by open-ended interviews to collect detailed views from selected participants. The research questionnaire was administered to a purposeful sample of 12 Heads of Research from South African HEIs. Both the questionnaire and interview response rate of five and 40.0% was achieved, which included participants from three comprehensive and two traditional universities. In total, five questionnaires and five interviews were undertaken: namely, two VCs and three Directors of Research or Innovation Centers.

3. Results and discussion

3.1. Results from the questionnaire. The core activities of the five HEIs revolve around three overlapping missions or mandates: teaching (undergraduate and postgraduate degrees), research (mid to long term), and community engagement activities.

3.1.1. Roles foreseen for HEIs' research in assisting the private sector. The suggested roles of HEIs' research in assisting the private sector are outlined in Table 2. In general, the respondents expressed that HEIs' research should be aimed at solving problems in the private sector. They also noted that both the HEIs and the private sector should play an active and collaborative role in research commercialization.

Table 2. Foreseen role for HEIs' research in assisting the private sector

HEI	Roles
1	♦ The private sector could plan and commission research from HEIs; the relationship will result in more solution-driven research. ♦ Research should be specifically aimed at solving problems in the private sector. ♦ Contract management, cooperation management.
2	♦ HEIs should undertake research activities that are informed by the private sector since the graduates will work with the industry. ♦ There should be collaboration between the HEIs, public and private sectors concerning research for purposes of mutual benefit. ♦ The HEIs should take the lead in enhancing the development of the communities where they are established; they should be community-based.
3	♦ Researchers may assist by doing consultancy work. ♦ The HEI has 36 THRIP* projects creating partnerships with industry. ♦ Technology transfer from the HEI to private sector. ♦ Corporate social investment projects initiated and managed by the participating institution. ♦ Knowledge creation and sharing through teaching and learning and research ending in publications.
4	♦ Research has implications for the private sector, although it may not assist it directly. ♦ Managing cooperatives with local business entrepreneurs. ♦ Contract negotiation. ♦ Developing new technologies for industry. ♦ Planning for collaboration, cooperation. ♦ Networking and seeking out external partners.
5	HEIs should: ♦ Undertake research for the private sector. ♦ Develop new technologies for industry. ♦ Commercialise research and create new businesses. ♦ Negotiate contract, manage partnership.

Note: *THRIP = *Technology and Human Resources for Industry Programme*

The suggested roles of HEIs' research in assisting the private sector are further illustrated in Figure 2. In the NSI schema the private sector, HEIs and Public Research Institutes (PRIs) synergize towards innovation. All of the respondents agreed that the HEIs should facilitate collaboration activities with the private sector. The fifth respondent stated that "HEIs are probably not designed in a manner that predisposes them to easily play that sort of instrumental role".

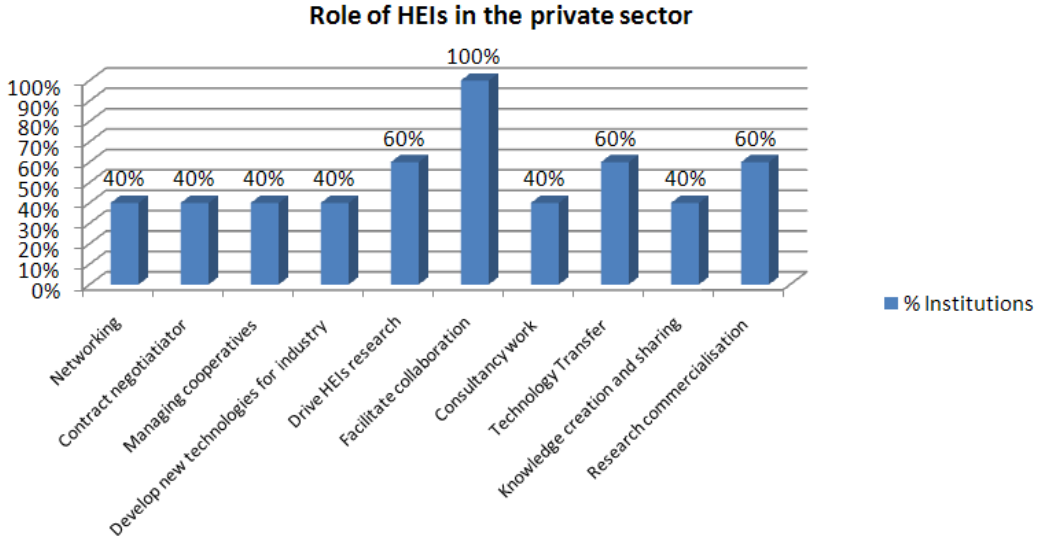


Fig. 2. Participants' views of the role of HEIs in the private sector

3.1.2. Discussion of questionnaire results. As indicated in Table 2 and Figure 2, the potential, unexploited HEIs-private sector partnerships represent an important alternative for driving research and sustainable development in South Africa. The inclusion of private sector linkages within the HEIs' strategic plans emerged as an important factor for research commercialization. Similarly, the strengthening and introspective development of concrete action plans within HEIs for effective deployment is required for research commercialization and sustainable development.

3.2. Results from the interviews. *Benefits (tangible and intangible) for engaging with the private sector in terms of research commercialization, community engagement and sustainable development.*

An outline of the tangible and intangible benefits accruing to the HEIs as a result of engaging with the private sector is set out in Table 3. According to the interview responses, benefits in the form of funds from the private sector were most commonly given in the form of student scholarships, academic excellence awards and graduate student research. Other forms of benefits included sponsorship of HEIs' chairs and seed grants, industry-commissioned research and technology development, and investments in HEIs' laboratories and equipment.

Table 3. Tangible and intangible benefits of engaging with private sector

HEI	Benefits of engaging with private sector
1	♦ Financial assistance and funding ♦ Rural integrated learning ♦ Employment of students
2	♦ Supporting events at the HEIs ♦ Placement and jobs for students
3	♦ Relevance of the university, increased prestige ♦ Programs' (research and community engagement) knowledge base makes the university very relevant ♦ Financially beneficial in terms of income, earning royalties ♦ Earning community engagement throughput where the university is a key player ♦ Opportunities for networks: staff and students benefit. In terms of the student placements, this allows them to know the private sector better and have better career choice and networks, that allows staff to further their expertise ♦ Social entrepreneurship ♦ Influence of research agenda coming from collaborative efforts with the private sector ♦ Meaningful investments
4	♦ Students' employment and placement ♦ Postgraduate research ♦ Funding of research
5	♦ Students' research ♦ Placement

3.2.1. Discussion of interview results. The findings showed that major tangible benefits accrued as a result of collaborating with the private sector, including: (1) networking and access to industry partners; (2) access to industry laboratories and equipment; and (3) journal publications. Benefits that have occurred to a lesser extent include: (1) ownership of licenses or patents; and (2) the creation of spin-off/start-up companies.

Intangible benefits have included an increase in HEIs' prestige as a positive externality of engagement with the private sector, enhanced graduate employability, skills development and internship opportunities, and increased contribution to community development. Intangible benefits that have occurred to a lesser extent include increased publications and networking, and enhanced revenue for the institution and staff.

Conclusion

Based on the findings, a number of conclusions have been identified as key requirements for expanding and strengthening human capital development within the HEIs. A key weakness of the condition of the South African NSI framework is the deficit in knowledge infrastructure such as HCD flow, both in terms of quantity and nature. Consequently, reforms are required in the schooling and training systems which have contributed to the consequent shortfall of well-equipped graduates and postgraduates, and in the production and retention of academics and researchers. Another notable weakness within the NSI is absence of ensuring the availability, collation, maintenance, analysis, monitoring and dissemination of HCD NSI performance. The finding also notes that the South African NSI is characterized by an imbalance in resource allocation. Large-scale national programs, such as the 'big science' projects and 'big technology' initiatives at the level of the NRF and the DST, have obscured other types of HCDs programs also critical for human capital development within the NSI.

South African HEIs have some mechanisms in place for engaging with the private sector. However, this type of engagement represents an emerging role, which is characterized by limited experience and expertise; resources are needed to drive the required collaboration forward strongly. The exclusion of the private sector from the NSI central policy platform and the persistence of an insulated, 'silos' mentality within the HEIs and some government agencies have contributed to the weakness of the NSI. The deep-seated gap between industry, government and the HEIs is rooted in a multiplicity of historical, political, philosophical and social factors that requires sustained attention in order to be resolved.

Recommendations

It is recommended that capacity building in relevant skill sets should be undertaken. An adequate knowledge infrastructure is a crucial condition for a well-functioning NSI. HCD interventions should be

put in place as high-level skills shortages have placed significant constraints on the transition to the proposed knowledge-based economy.

Strategies to strengthen HCD in South Africa should, therefore, include:

- Increased investment in knowledge infrastructure/ skills bases,
- Reformed immigration policies for mobility of skills,
- An internationally open system, and
- Fostering HEIs-industry linkages by encouraging reciprocal access to equipment, research cluster centres, incubators and technological and industrial parks.

The proposition is that for knowledge transfer between the NSI actors to occur, provision of an enabling environment to bridge the knowledge gaps should be implemented. Transition from a resource based into a knowledge based economy should entail well-designed, systematic and deliberate executed interventions and governance mechanisms targeting the NSI. Therefore, the governments should put in place a conducive, incentivized environment for strengthening the HEIs HCD by putting in place policy frameworks for Science & Technology strategies. Additionally, the government should also provide incentives and funds for eliminating constraints and stimulating both demand-pull and supply-push approaches for HCD uptake.

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