



Research Article

# The Evolution of Universities to Address Innovation Systems Performance

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## Abstract

The need for universities to evolve into active participants in innovation systems became eminent over recent decades. The evolution is evident in changes from development of human capital and knowledge creation to the inclusion of knowledge dissemination and transfer. The changing roles of universities contribute to the impact of innovation systems on economic growth, as emphasized in neo-Schumpeterian economic growth theories. South Africa is a country with high rates of poverty and unemployment. The improved performance of the South African innovation system is essential for the economic development of the country. In this article, the South African universities are evaluated to determine to what extent they have been changing to include the role of knowledge dissemination. The importance of this paper lies in the contribution to evolutionary economics literature on the evolutionary roles of universities in innovation systems. The paper is further intended to raise awareness of the changing roles of universities' contribution to the innovation system of South Africa.

**Keywords:** knowledge dissemination, universities, innovation systems.

## Introduction

Innovation is key to economic development. Economists have in the past three decades increasingly studied the role of innovation and the impact of innovation systems on economic growth and development (Heertje, 2006; Hanusch and Pyka, 2007; Freeman, 2008). An innovation is defined as a system that consists of the participants or actors and their activities and interactions, as well as the socio-economic environment within which these actors or participants function, that together determine the innovative

performance of the system (Eggink, 2012). Universities play an important role in national innovation systems. The change in the role of universities, as actors in innovation systems, coincides with the change in views in economic theory from neo-classical theories to evolutionary neo-Schumpeterian economics (Etzkowitz and Leydesdorff, 1997:3; 156; Liefner and Schiller, 2008:280). Evolutionary economic theories emphasise the importance of innovation in economic theory. Universities globally are becoming more active in contributing to the performance of innovation systems (Greenhalgh and

Rogers, 2010; Mowery and Sampat, 2005). The roles of universities have changed from only teaching to also include knowledge creation and knowledge transfer (Gunasekara, 2006; Wong, Ho and Singh, 2007; Bramwell and Wolfe, 2008; Youtie and Shapira, 2008; Peterson and Rumbelow, 2008; and Kaymaz and Eryigit, 2011).

South Africa is a country that needs to improve its innovation system performance, due to high poverty and unemployment rates. The unemployment rate in South Africa for the first quarter of 2016 was high at 26.7% (Statssa, 2016:iv). Poverty rates are alarmingly high in South Africa with 45.5% (2011) of people regarded as poor, implying that they earn less than R620 per month (the amount considered necessary to purchase both adequate food and non-food items) (Statssa, 2014). In global terms, the poverty headcount (of those earning \$1.90 a day or below (2011 purchasing power parity) is 16.6% (2011) of the population in South Africa, compared to 12.7% (2012): the world average (World Bank. Data (a)). In the light of the dire need for growth and development in South Africa, all the role players in the innovation system, including universities, should participate in and contribute to enhancing the performance of the national innovation system.

The research question is: how have South African universities adapted to the changing role in tertiary education? It is the aim of this paper to determine if and how South African universities are responding to the increased need to contribute to the performance of the national innovation system.

A literature review is first conducted on the historic and current changes in the roles of universities in innovation systems globally. The case of South Africa is then studied and the roles that universities play in South Africa's national innovation system are evaluated and reported on. There are not specific measurement tools for knowledge creation and knowledge dissemination. Therefore triangulation - by means of a combination of measurement tools - has

been used to evaluate the changes in these vital functions of universities. This study aims to contribute to the literature on the importance of the changing role of universities in innovation systems, as well as to the improvement of the performance of the national innovation system of South Africa.

### **A historical overview of the changing role of universities**

The importance of education and training institutions in the performance of innovation systems is highlighted by Goldstein (2009:11), who states: "There is no question that universities increase aggregate regional economic activity... Empirical studies using regional production functions have shown that universities, on average, lead to increases in productivity growth and innovation in the region, controlling for other factors". It should, however, be noted that universities are not all the same and the roles that they play in their innovation systems may vary (Goldstein, 2009:15; Jansen *et al*, 2007:181).

Although literature on the changing role of universities has increased significantly over the past three decades, changes are not confined to this period. The role of universities has been changing since the establishment of the first universities in the twelve century. Medieval universities were characterised by the accumulation of knowledge, but they became more active in terms of knowledge generation at the beginning of the nineteenth century. Universities took on a stronger role in scientific research "based on rational inquiry and experimentation" and the Humboldt University in Berlin became the model for such practice. Universities further expanded their roles to research and training in technical disciplines and began educating students to meet the needs of industry (Youtie and Shapira, 2008:1189; Brockliss, 2000). Over the past few decades, the focus has shifted again: from training students and conducting research ("knowledge factories") to becoming more active in development and innovation ("knowledge hub") (Youtie and Shapira, 2008:1189). Wissema's (2009:3-4)

identification of three distinct periods in the evolution of universities accords with the account offered by Youtie and Shapira: the first generation university or medieval university; the second generation university or Humboldt university (currently falling into obsolescence); and the third generation university, or 3GU, that is the university still to come. Some of Wissema's time periods or phases overlap and between the three phases there are transition phases. Wissema contends that universities are currently in a transition phase between being second and third generation institutions.

Sutz (1997:10) describes the changing role of universities as moving from a "two-role model" of teaching and research to a "three-role model", adding the focus on a direct relation to society: "In former times, the university as such – with very few exceptions – did not carry out the functions that are characteristic with the firm or enterprise: it did not market its capacities, it did not enter into agreements specifying the article to be delivered or the delivery date, it did not compete with either university or non-university agents to sell its intellectual production... Nowadays, the university has become a direct producer of goods and services for end-users".

Wissema (2009:45-46) classifies universities' quality of research and education according to the progress they made towards the third generation universities. Wissema identifies five types of universities: universities with an emphasis on education only (higher professional and scientific); universities with a solid research base and research-based teaching; universities active in research and research-based teaching and with commercialisation facilities; universities with cutting-edge research and excellent teaching capabilities; and universities with cutting-edge research and education and strong commercialisation. Liefner and Schiller (2008) follow a similar reasoning by including more categories and classifying universities as low, intermediate or advanced in terms of different teaching, research, functional and organisational capabilities, according to both quantitative

and qualitative criteria. Wissema, as well as Liefner and Schiller, imply therefore that universities should fulfil all three roles (teaching, knowledge creation and knowledge dissemination). The worldwide trend for universities to change their roles to include knowledge dissemination and transfer, points to evolution in order to adapt to demand from industry and communities and highly competitive environments.

Next, the role that South African universities play is evaluated and reported on in order to establish if the South African universities have followed the world pattern of evolving to include knowledge dissemination and transfer.

### **The case of South Africa**

South Africa's universities are evaluated regarding their role in the creation of knowledge on the one hand, and diffusion of knowledge on the other. The data for South African universities are compared to those of the country's main trading partners (US, Japan, Germany, Botswana, Namibia, UK, the Netherlands, Switzerland) (South Africa Data Portal) and the BRICS countries (Brazil, India, Russia and China), where available.

### ***The creation of knowledge role of universities in South Africa***

The quantitative criteria used to evaluate South African universities in terms of knowledge creation include research outputs, R&D expenditure and patent registrations. South Africa's share in research publications worldwide increased from 0.49% (2000-2004) to 0.59% (2006-2010) (Pouris, 2012:5). In Table 1 countries are ranked by number of research documents for 2013. Ranking has been done for 229 countries, but the table only shows selected countries. South Africa is ranked 34<sup>th</sup> in the number of research publications, which is fairly high considering the fact that South Africa only ranks 79<sup>th</sup> in GDP per capita. If the number of research documents is compared with the population, South Africa then only ranks 67<sup>th</sup>, but South Africa ranks a high

19<sup>th</sup> with regards to research outputs per GDP per capita (purchasing power parity).

**Table 1: Research outputs, population size and economic performance**

Country	Documents	Rank (number of research publications)	Citations per Document	<i>h</i> -index	<i>h</i> -index Rank	Population	Population Rank	Number of research documents per size of population Rank	GDP per capita ppp (constant 2011 international \$)	GDP per capita ppp (constant 2011 international \$) 2013	Number of documents per GDP per capita ppp (constant 2011 international \$) 2013 Rank
United States	563292	1	0.64	1518	1	316 128 839	3	23	51 451	10	3
China	425677	2	0.30	436	16	1 357 380 000	1	64	11 525	82	1
United Kingdom	162574	3	0.70	934	2	64 097 085	22	13	35 041	26	4
Germany	148278	4	0.70	815	3	80 621 788	16	21	42 045	17	6
Japan	121668	5	0.44	694	6	127 338 621	18	37	35 481	25	7
France	108092	6	0.63	742	4	66 028 467	21	26	35 969	24	8
India	106029	7	0.28	341	23	125 213 9596	2	97	5 238	119	2
Brazil	59111	13	0.31	342	22	200 361 925	5	66	14 555	72	5
Netherlands	50939	14	0.85	636	8	16 804 224	60	9	41 980	18	20
Russian Federation	43930	15	0.30	355	21	143 499 861	9	65	23 564	43	15
South Africa	<b>15181</b>	<b>34</b>	<b>0.54</b>	<b>260</b>	<b>34</b>	<b>52 981 991</b>	<b>24</b>	<b>67</b>	<b>12 106</b>	<b>79</b>	<b>19</b>

Sources: SCImago; The World Bank. Data (b)

South Africa ranks high in terms of R&D expenditure by higher education as a percentage of GDP per capita (12<sup>th</sup> of 26 countries), as indicated in Table 2. Table 2 shows the R&D expenditure of higher education and the GDP per capita of a selected group of countries (where data

were available from the OECD database). South Africa's R&D expenditure by higher education ranks 18<sup>th</sup> of the 26 countries. However, the rank of R&D expenditure as a percentage of GDP per capita may be better due to the relatively low GDP and not necessarily the high R&D expenditure.

**Table 2: R&D expenditure by higher education as a percentage of GDP per capita**

Country	2010 R&D expenditure by higher education (2010)	Rank of countries by size of R&D expenditure	GDP per capita ppp (2005 constant prices)	% of R&D expenditure of GDP per capita	Rank of countries by % of R&D expenditure per GDP
Japan	16564829	1	30886	53.63	1
Germany	13911208	2	34465	40.36	2
United Kingdom	9791927	3	34129	28.69	3
Russian Federation	1906165	10	14136	13.48	9
South Africa	97419	18	10564	9.19	12

Source: OECDStatExtracts

Patent registration is another quantitative indicator of knowledge creation. The World Intellectual Property Organisation (WIPO:2014) reported on the contribution to patent registration by universities of different countries, making use of Patent Cooperation Treaty (PCT) data. The total number of PCT applications from the top five universities in each region is provided. The top five universities in Africa are all from South Africa and they contribute 61.2% of all applications in Africa. The total number of applications from Africa, on the other hand, only constitute 0.56% of applications from top universities of all 148 PCT member countries. South African universities perform well regarding patent registrations in comparison with the rest of Africa, but in world terms these numbers are insignificant.

One of the indicators that is used for quality of research publications is the *h*-index, listed in Table 1. The *h*-index does not only include the number of publications, but the number of times the publications were cited as well (Hirsch, 2005:5). The *h*-index is developed for an individual researcher, but can be used for a group of researchers as well (Van Zyl, 2012). South Africa ranks 34<sup>th</sup> in the *h*-index, which is high for a developing country. If it is taken into consideration that South Africa's economic performance ranking, as indicated by GDP per capita ppp, is only 79<sup>th</sup>, South Africa's research outputs and *h*-index are higher than expected; but for the size of the population

(ranking 24<sup>th</sup>), the outputs are lower than expected. If we compare South Africa to the US (ranked number one for number of citations and the *h*-index), the US had at least 1518 citations of 1518 published articles, where South Africa had only 260 citations of at least 260 published articles (Van Zyl, 2012:2). The *h*-index indicates that the quality of South African publications are not comparing well with that of its trading partners and other BRICS countries.

Another index indicating quality of publications is the relative activity index. A value of one indicates that the South African article in a certain discipline attracted the same number of citations as the average article in the discipline in the world (Pouris, 2012:4). Pouris (2012) developed a list of the relative citation indices for South Africa for different disciplines for the periods 2000-2004 and 2006-2010. The overall index increased during these periods from 0.69 to 0.88 and the index decreased for only three disciplines out of the 22. Although the South African articles do not attract as many citations as that of the average articles in rest of the world, there has been an improvement.

#### ***The knowledge diffusion role of universities in South Africa***

To determine to what extent South African universities have followed the world trend in changing their role to include knowledge

diffusion and dissemination, criteria such as number of or time spent on formal, informal, direct or indirect linkages between the universities and other innovation system participants or role players must be employed. Diversity of linkages and lack of databases of linkages make local and international comparisons difficult. Nevertheless, the available data give some insight into the extent to which South African universities fulfil the role of knowledge diffusion.

In order to place South Africa in a global perspective, the results of a study by the OECD (2013) provide valuable information. The study indicates that 16.2% of SMEs and 37.0% of large firms collaborate with higher education and public research institutions on innovative activities in South Africa. The corresponding percentages for Germany are 13.9% and 43.2%, Japan 18.7% and 37.3%, the United Kingdom 16.8% and 31.3%, and Brazil 4.6% and 18.0%. Although the South African percentages compare well with many developed and emerging countries, it should be noted that the larger firms in South Africa collaborate more with universities than SMEs. It should, however, be more important for smaller firms to make use of the knowledge produced by universities, due to the lower R&D expenditure of SMEs. In less developed countries, the R&D expenditure is also lower than that of developed countries, which again increases the importance of university knowledge dissemination.

Another study on the linkages of universities with industry is the one conducted by Higher Education South Africa (HESA, 2012). This study reported on a survey conducted by the Human Sciences Research Council (HSRC) on behalf of HESA of a sample of 2 159 academics from five universities in South Africa (a rural university, a university of technology, two research universities and a comprehensive university). This survey was done with the aim of determining the scale and forms of interaction between the universities and firms, communities, local government or development agencies. The total number of academics who engaged with external social partners is high in that

81% of the academic staff members reported that they had interacted with external social partners. Of these academics that indicated that they had engaged with external social partners, 58% engaged with SMMEs, 56% with large South African firms and 42% with multinational enterprises (MNE) (HESA, 2012:10).

Although the percentage of academics who engaged with external partners was high, it does not imply that these interactions were direct or had a direct influence on the firms in question. HESA (2012:11) developed a matrix of university-industry interaction and distinguishes between four forms: traditional, networked, dominant new and entrepreneurial. Traditional forms are long-standing and primarily financial such as donations and sponsorships and dominant new forms of interaction include, for example, consultancies and contracts. Entrepreneurial forms of interaction are commercialisation of intellectual property (such as spin-off companies) and collaboration with existing companies by means of royalties, licences, patents or venture capital where both the university and the firm are motivated by financial gain. The networked forms are knowledge intensive forms of interaction, often government funded and aimed at developing R&D and innovation. Most linkages are of a traditional nature and related to teaching activities. There is a fairly high degree of networking as well, but mostly with SMMEs. The entrepreneurial forms of interaction occur the least and there is little commercialisation of new products, especially in collaboration with larger firms.

HESA (2012:14) expanded the examination of university-industry linkages in South Africa by investigating the channels through which interaction is facilitated. The channels most indicated by academics were informal information exchange and conferences, seminars or workshops. Technology networks, patent applications and spin-off forms seem less common. The findings of HESA are confirmed by a study of ten South African universities by Pouris (2006), which analysed the time spent by

academics on different activities. Pouris (2006:15) found that academics spend most of their time on administration and undergraduate teaching; the time spent on R&D activities ranges between 12% and 15% for professors and associate professors and between 6% and 10% for senior lecturers and lecturers; and academics spend less than 3% of their time on patent and innovation related activities. Pouris found that the time spent by academics on R&D and innovation related activities is substantially lower than that of other countries.

The quantitative data provide a clear description of the extent of involvement of universities with external role players. The linkages and channels are mostly related to core educational functions and therefore contribute to human capital capacity building and to some extent knowledge creation. Knowledge diffusion linkages are less prominent in South African universities. Kruss (2008) concluded from eleven case studies concerning technology cooperation networks in South Africa that "...the intellectual capacity to develop cutting edge high technology products exists within some South African universities, that there is a degree of entrepreneurial and interactive capability that can create spin-off firms, and that there is a degree of government funded support for such initiatives. However, the empirical analysis showed that despite a favourable policy and funding context, it is extremely difficult and complex to sustain a competitive knowledge-intensive university spin-off firm in South Africa." Although there is proof of some knowledge diffusion activity, the data have not indicated the quality of the different forms of interaction and linkages.

### **Conclusion**

Universities play an important role in innovation systems and the historical role of universities has changed. Universities have moved from knowledge accumulation to knowledge creation and, in recent years, to knowledge transfer and dissemination. The change over the past thirty to forty years coincides with an evolution in economic views, focusing on the role of

innovation in economic development and the study of the innovation system as a complex relationship between many role players or participants. Universities are key participants in the innovation system. Although these changes in the roles of universities are a general trend worldwide, it does not imply that all universities followed the same trend. There are differences in the extent of the roles that universities play in developed and less developed countries.

In order to develop in South Africa a well-functioning national innovation system, universities have to follow the current trend in higher education to include knowledge transfer and dissemination as functions. This paper reported on the state of South African universities in this regard.

The evaluation of South African universities revealed that, although there are individual exceptions, the universities in South Africa on the whole do not play a strong enough role in the national innovation system to contribute sufficiently to the economic development of the region. The performance of South African universities, with respect to the creation of knowledge, compares well with the rest of the world. This finding is contrary to what is expected in light of the size of the economy.

The evaluation revealed that South African universities have not yet followed the world trend of including knowledge transfer and dissemination as roles. Although most university academic staff members have indicated in a study by Pouris (2006) that they have linkages with industry, these linkages are related to the core education function of their universities, and not to innovation, R&D or commercially-related activities.

This study focussed on the macro performance of universities and not on individual universities. Although it is clear that the performance of South African universities has to improve in order to contribute significantly to the performance of the national and regional innovation systems, it does not imply that all universities have to perform the same

functions or at the same level. The diversity of South Africa's universities is important in order to address the different demands of the country. Furthermore, roles and functions, or perhaps the activities in carrying out these roles, may be different in developing countries due to developing countries' need to adapt rather than create technology.

It should also be noted that the presence or quality of a university does not ensure high performance of an innovation system. Higher education is only one of the participants in the innovation system and if the other participants do not contribute fully, and if the environment is not conducive for innovation to take place, innovation and development of the system will not be successful.

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