African Journal of Hospitality, Tourism and Leisure Vol. 3 (2) - (2014)
ISSN: 2223-814X Copyright: © 2014 AJHTL - Open Access- Online @ http//: www.ajhtl.com

Research and Innovation – the drivers of economic development

Prof Angelo Nicolaides
UNISA Graduate School of Business Leadership
nicola@unisa.ac.za

Abstract

Research and development are critical fueling innovation and national development and economic growth, but there also needs to be apolitical will to succeed. Furthermore there must be a strong synergy between academia and industry. Thus, for research to yield practical fruits, the results must enlighten and mould socio-economic policies and be readily adaptable to the needs of society. Is scientific research being conducted that impacts positively on society, that saves lives? Are there increasing numbers of technological innovations that make South African companies more competitive? Does social science research enlighten public policy? Does current humanities research support the arts and culture? Do ideas emanate from South Africa that improve the quality of life domestically and gobally? South Africa's Universities in particular have a vital role to play in developing the nation and they are critical to success in a knowledge-based economy.

Keywords: research, innovation, development, growth, developing countries.

"Innovation distinguishes between a leader and a follower."
(Steve Jobs - Apple co-Founder)

Introduction

There are well documented examples of the strong relationship between innovation and economic growth and while there are a myriad of results supporting this notion, these are invariably always plagued by a series of caveats which state the many inherent limitations of empirical findings supporting the notion. There are thus many assumptions as to the relationship betwixt innovation and economic development (Statistics Canada, Innovation Analysis Bulletin, 2002). It has been ascertained that there is a direct positive connection between research and development (R&D) investment and levels of economic development and growth. The significance of research and innovation in attaining vital economic growth in developed nations has been resolutely recognized by a number of theoretical and empirical studies such as those of Adam Smith (1776), Schumpeter (1934), Solow (1957). The essential relationship between innovation and development has also been demonstrated by a number of researchers *inter-alia*, Allen (1967), Rothwell and Robertson (1973), Mansfield (1977), Ebadi and Utterback (1984), Jaffe et al (1986) and Stratmann (2005).

As early as 1776, Adam Smith recognized the hypothetical linkages between innovation and economic development. He states in *An Inquiry into the Nature and Causes of the Wealth of Nations,* that:

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"Many improvements have been made by the ingenuity of the makers of the machines, when to make them became the business of a peculiar trade; and some by that of those who are called philosophers or men of speculation, whose trade it is not to do anything, but to observe everything; and who, upon that account, are often capable of combining together the powers of the most distant and dissimilar objects. In the progress of society, philosophy or speculation becomes, like every other employment, the principal or sole trade and occupation of a particular class of citizens… and the quantity of science is considerably increased by it. " (Smith, 1776).

Schumpeter (1934) was the first economist to highlight the significance of innovation as a driver of economic development. He states: "the introduction of new or improved products, production techniques and organization structures as well as the discovery of new markets and the use of new input factors" are important considerations. He maintained that competition via innovation is the driving force of economic development and thus promoted innovation as a critical factor (Schumpeter, 1934).

It was however Robert Solow (a Nobel laureate in Economics in 1987) who in 1957, first brought innovation *per se*, into the domain of formal economic growth models. He stated that technological improvements are the foremost drivers of economic growth, thus promoting an externality perspective or exogenous notion as to the value of human capital. He characterized technological improvements or developments as the improvements in diverse business processes or products and maintained that these improvements turn out to be the innovations which facilitate economic growth. Solow also showed that technical advancement is essential for there to be continued growth in output per hour worked. Growth was defined by him as the enlargement in GDP per hour of labour per unit time. In the 1950s, it was postulated that the amassing of capital was the primary determinant of development. Given this environment, he measured the portion of growth that was in reality attributable to increases in capital accumulation, including *inter alia*, investments in machinery and other requisite equipment. Solow in a sense oversimplified the situation and was not entirely certain but hypothesized that new technologies drive economic growth and lead to "technical change". The relationship between innovation and development has been further developed by Paul Romer (1990) and Robert Lucas (1988). Romer (1990) explained that endogenous growth is created by accumulating technology (or knowledge), and by ascertaining a relationship between the level of human capital and economic development. Human capital leads to technological growth and is thus viewed as 'knowledge' and 'ideas' that are not in opposition to each other. Lucas theorised that it is human capital formation alone that, by non-decreasing minor returns, creates growth without any external cause. He modeled human capital as having continuous rather than moderate returns, and proffered valuable insights into the significant role of having a highly skilled workforce for long-term development.

Romer on the other hand, believed that innovation has no external cause in the development model by introducing "knowledge spillovers", which ultimately gave birth to profound implications as to how intellectuals conceive of development. Basically then, when a company increases its investment in capital, it is not only increasing its own production levels, but also those of neighbouring companies. Romer and Lucas handled some empirical incongruities by altering their ideas about how capital and labour are combined to produce economic output (Romer, 1994). They both proposed that

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technology, human capital and knowledge in national economies make productive ones even more productive. Knowledge is essential for productivity because it is freely accessible and knowledge production invariably leads to more knowledge production. By means of contrast, companies need to pay often huge sums of money for labour and technology needed to produce goods.Gaillard (2008) asserts that research and innovation comprises all fields of Science and Technology including the natural sciences, social sciences, engineering and humanities. The Organisation for Economic Cooperation and Development (OECD) in1963, meeting in Frascati, Italy, defined R&D as "creative work undertaken on a systematic basis in order to increase the stock of knowledge, including knowledge of man, culture and society, and the use of this stock of knowledge to devise new applications" (Frascati Manual 2002). Knowledge is vital to development since it can be used by many companies at the same time and generally it is free to access. Consequently, knowledge reduces production costs for companies in the same industry and productivity grows. Countries with greater levels of knowledge production invariably develop relatively faster than nations in which there is less knowledge production. Companies generally support R&D as it leads to greater financial bottom lines and thus also enables them to consider the triple-bottom-lines of profits, people and planet and enhances their abilities to become effective corporate citizens.

When companies provide funds for R&D they expect a return on their investment (ROI). Knowledge production which is highly useful is that type which the company can utilize and have unique access to. The second type of knowledge is not appropriable and supports the general good and many companies can access this knowledge. The greater the amount of knowledge available the more useful and viable R&D efforts become and the greater the amount of human resource inputs become to the acquisition of knowledge which is used to increase profits. Companies thus increase knowledge in society as a 'spillover' effect. In this model, there are invariably greater returns from investment made in human capital and R&D. It thus stands to reason, that the greater the human capital in an economy, the greater the value accrued from R&D. This leads to greater R&D and thus there are more 'spillovers' and so the cycle continues. The 'spillovers' are critical to innovation and growth.

In this article the author assumes the linear model is applicable. This predominantly founded on the assumption that there exists a strong causal relationship between research/innovation and economic development and growth. If one considers the analytic scheme of Gerryts and Buys (2008), the discreet stages in the linear innovation model are firstly research, secondly development and thirdly production and marketing. The global economy is transforming all the time and since borders have become more permeable, this has led to a great expansion in international trade which has led to significant efficiency gains in the provision of resources and technologies. There is now far greater transparency and stronger interconnectedness within the global economy. This has led to huge international competition in which nations vie for much needed capital, R&D and innovation, thus enhancing the projection for growth through augmented efficiency. Link (1982) views research as being predominantly focused on the investigation for technical or scientific advancement and development. Furthermore any advancement is to be translated into product or process innovation. It is evident that research that is undertaken both academically and commercially is a solution to and vital for any economic development.

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Nations such as the USA and China are at the zenith of the list of the world's premier economies because of their vast allocation of resources into fostering innovation. Innovation and R&D are the drivers of development and prosperity. It has been suggested by renowned economists such as Milton Friedman and others that approximately 50% of the USA's annual GDP growth is directly or indirectly ascribed to increases in innovation and R&D. South Africa should be increasing the competitiveness of its economy by increasing research and innovation, with the main impact at the level of companies. More knowledge must be transferred into economic practices and into improving societal quality. We thus need to seek novel technical and scientific methods which sustain social development and improve the human dimension.

What is innovation?

Innovation assumes a number of forms and includes processes, products, services, or in fact anything that assists companies and nations to perform in an improved fashion. As such, innovation can be created by any person who is innovative in spirit and who possesses a frame of mind capable of exploring existing boundaries. When we speak of radical innovations, these consist of totally new products which are often carried out by new entrants with a diversified knowledge base. Where there are simply minor improvements in existing products and processes, this is termed incremental innovation. Such innovation is usually positioned within companies with specific knowledge bases. Creating new knowledge, through research and innovation gives a nation a leading edge in especially the scientific and technological realms. Innovation and research is generally in a number of areas including organizational, technological, product, process, and marketing. Innovation is thus critical to bolster a nation's competitive advantage at the global level. As research is conducted and innovative ideas evolve, creativity grows and new ideas are brought to fruition and these ideas when implementable produce new value. Whereas improvement as such is the fine-tuning of existing methods to obtain greater output from the same input, innovation breaks new ground as it provides novel outputs from less or different inputs. The impact of innovation results in huge leaps in value creation that includes far more effective outputs. Innovation contributes greatly to economic growth and development in a national economy and to the global economy in general.

The output of the national economy can be improved in one of two ways. Firstly, the number of inputs into the productive process can be increased or we can think of new ways to obtain greater outputs from the same number of inputs. Either way, innovation is often a complex development of inventions and new discoveries, For example new machinery can be brought into the business environment and market and may optimistically lead to diffusion as it is adopted by new users. Innovation thus includes product and process innovation. In the first case new products or services are introduced while in the second, innovation alters the way in which a product is manufactured in a company and disseminated across the supply chain. Of course during the diffusion of a product into the market further improvements to the original idea can be considered and further innovative thought and research is often required so as to fine-tune the innovation. It is more often than not the case that once an innovation is relatively successful other industry players tend to imitate it (Lehtoranta, 2005). Where organisational routines are altered or replaced with new ones, this is termed behavioural innovation. It is usually the case that innovation is a combination to a lesser or greater

extent of all three categories. A totally new product may require additional production competencies and skills and may thus necessitate changes in the organizational structure and processes.

Technology which results from research and development is often at the heart of an innovation. But it must be remembered that innovation is not merely creativity but that it begins with an idea and the subsequent implementation thereof to create new value. Innovation is ground-breaking and leads to fresh outputs from less or dissimilar inputs and generally results in huge jumps in value creation for all role players and it includes the introduction of known things to fresh markets or perhaps even to totally different industries. An innovation may be something related to the past accomplishment of the innovator or to the domestic or global market.

A few examples of South Africa initiatives

South Africa is clearly capable of exceptional R&D and is one of the hosts the Square Kilometre Array (SKA). This is the most powerful radio telescope ever invented. The SKA will be the world's largest radio telescope and will be hosted by inter alia, South Africa. It will be about 50 – 100 times more sensitive than any other radio telescope on Earth, the will be capable of probing the outer edges of the Universe. This is but one of many areas in which South Africa is an important player in the global arena of R&D and innovation.

Regionally, the role of South Africa in SADC and in NEPAD (New Partnership for Africa's Development), regarding water resources and water supply and sanitation issues, cannot be underestimated and it presents many new challenges and necessitates many initiatives in which the country takes the lead. Amongst the many initiatives there is also the Support Programme for Industrial Innovation which is managed by the Industrial Development Corporation of South Africa Limited (IDC), on behalf of the Department of Trade and Industry (DTI). It promotes and supports technology development in South African industries via the delivery of financial assistance for projects that focus on developing innovative products and/or processes. The Advanced Manufacturing Technology Strategy (AMTS) is a programme that is managed by the Technology Innovation Agency. It is funded by the Department of Science and Technology and focuses on the automotive and aerospace industries. It relies on extensive collaboration initiatives amongst industry, academia, and the various science councils.

The Technology for Women in Business (TWIB) is an initiative that is sponsored by by the DTI and it is primarily aimed at improving the accessibility of science and technology to women in business. It is particularly concerned with small, medium and macro enterprises (SMMEs). There are many examples which could be given to demonstrate the commitment of South Africa to becoming a knowledge based economy. The road ahead is nonetheless daunting.

Governmental role in innovation

The Department of Science and Technology (DST) in South Africa is the custodian of scientific research in the country and administers the management of the country's well-

ISSN: 2223-814X

developed science system. The DST strives to achieve the full potential of Science and Technology (S&T) in areas of social and economic development, via the improvement of human resources (HR), and particularly through research and innovation. Their main objective is to effectively implement the National Research and Development Strategy (NRDS). It is this strategy which makes provision for an integrated approach to HR development, knowledge generation, investment in infrastructure and improving the strategic management of the public science and technology system. The DST further promotes South African science and innovation by developing science, technology and innovation policies, by funding Research and Development (R&D) at public research institutes and universities and by creating new institutions and instruments which are aimed at augmenting the impact of science on society. The Department also forges links with other state departments, more especially those that enjoy oversight responsibilities over science related agencies (SAccess 243851)

Innovation and particularly research and development (R&D), has a vital role in to play in the restructuring of the South African economy. The National Industrial Policy Framework (NIPF), suggests that the primary fault in the South African economy is the country's relatively poor performance when it comes to non-traditional tradable goods and services in addition to the fact that the government needs to further subsidize research and development disbursements so as to bring investment up to the desired levels. There is a huge significance of innovation due to R&D to the national economy, Furthermore, it clearly pushes greater efforts towards socio-economic transformation (Fagerberg, 1988). The National R&D Strategy published in 2002 suggested that there should be a doubling of government investment in science and technology during the period 2004 – 2008.

The Organisation for Economic Cooperation and Development (OECD) (2009) reviewed South Africa's innovation policy of 2008 and stressed that it is vital that the economy be restructured away from depending on resource-based industries. What is deemed necessary is a shift to knowledge intensive economic activity. Innovation, technology and economic development are achieved via the intricate relationships that exist between the various actors and institutions within any national system and in various economic sectors (Malerba, 1999). For a nation to improve its economy, there needs to be a clear application of knowledge in productive activities and this should be supported by concomitant adjustments in the social institutions and extensive increases in total expenditure on R&D/GDP) to over 1%. Such spending will signal an apposite and sustainable strategy for a developing knowledge based economy. Additionally, it is for example the government's task to institute and enforce intellectual property rights through effective patent and copyright laws. Such support would ensure that the innovator has some control, and this provides the private inducement to conduct research. Knowledge generation and dissemination are critical to success.

The resultant knowledge may then be dispersed through carefully constructed licensing and emolument contracts. South Africa is at the bottom end of spending on R&D as aa percentage of GDP (see figure 1). South Africa needs to concentrate on bringing into line the supply side elements of innovation such as support of research, development and innovation (RD&I) with the demand side elements of innovation such as commercial activities. In this regard a national innovation system will guide and empower policy-makers to align the supply side with the demand-side of technology elements.

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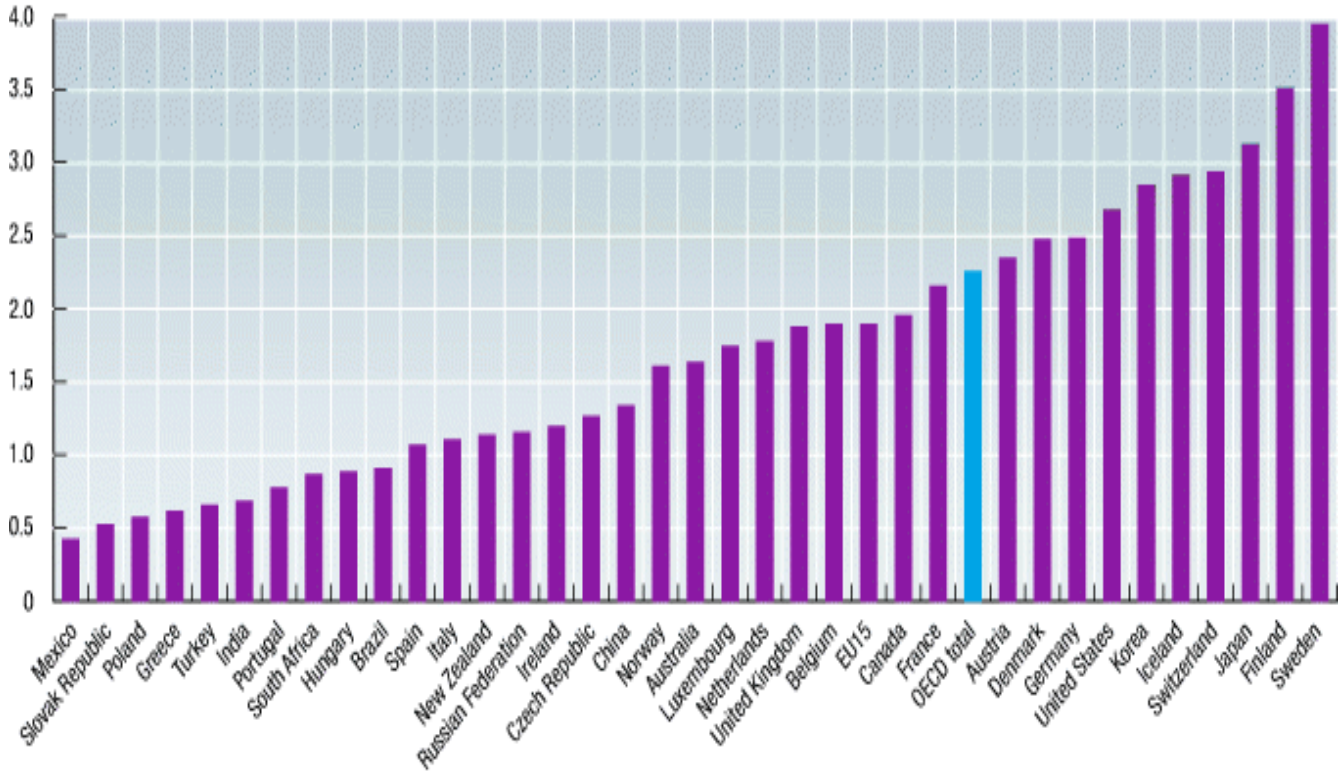
It is good to note that the South African National Treasury states that the budget of various public institutions and agencies involved in research, development and innovation had risen to R9.017 billion for the 2011/12 financial year and this is indeed a very positive step forward.

Figure 1: Gross Domestic Expenditure On R&D as a percentage of GDP, latest available year
Source: OECD Library



Global development and innovation

The global economy is slowly recovering from the economic and political intrigues that have plagued it since 2001 and the global economy is increasingly looking to the emerging economies (Gurria, 2007). Since 2006/7 the developing nations have steadily grown. It is highly likely that in the next two decades, emerging economies will represent almost two-thirds of global output. The main reason for this is innovation which can be derived from any place.

The global economy is highly interdependent, and more so than ever before as is evidenced by ever-increasing exchanges of goods, services, ideas, values, expertise in various fields, and in the manner in which solutions are sought to solve global problems. Companies in developing nations are called upon to conceive and develop revolutionary and progressive products and processes since this is the way they will be able to retain a competitive advantage. Consequently, business investment in R&D is in a sense non-negotiable. Top-notch scientific research institutions are undoubtedly an essential

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partner in innovation and there is also a need for far greater collaboration in research promotion between industrial role-players and universities.

By enhancing research and boosting innovation, economic growth is bolstered and developing nations are empowered to create new and very often, unique products and services (Agrawal, 2002). Such developments are shared globally and good ideas that are ours remain ours.

Many studies confirm that there is indeed a very positive correlation between the amount of R&D and productivity growth and R&D positively impacts on total factor productivity as such. Human capital improves and inflows of foreign direct investment (FDI) tend to soar (Agrawal, 2002; Martino, 2009). As we create, disseminate and apply knowledge we boost economic expansion. Innovation is a fundamental starting place of effective competition and economic development. It is critical to transforming society. Economic growth across sub-Saharan Africa has been comparatively huge in recent years, as is exemplified by a GDP growth expected to be in the region of 5.3 per cent by year end 2014. Innovation is for the most part vitally important for nations that have reached what is termed the 'high-tech frontier', as this is the only self-sustaining driver of growth (Romer, 1987). This necessitates an environment that is favorable to innovation and one in which both the public and the private sectors are key players. Innovation may assume a variety of types and may be a process, product, service, or anything that assists companies and nations to achieve more. Innovation is within the potential of anyone but necessitates a critical view and inquisitiveness that enables one to explores perceived limitations and develop new designs and initiatives. South Africa is growing its technology trade but has way to go when compared to the other BRICS members (See Figure 2).

Figure 2: International trade by technology intensity: Growth of high- and medium-high-technology exports, 1997-2007 source: OECD Library

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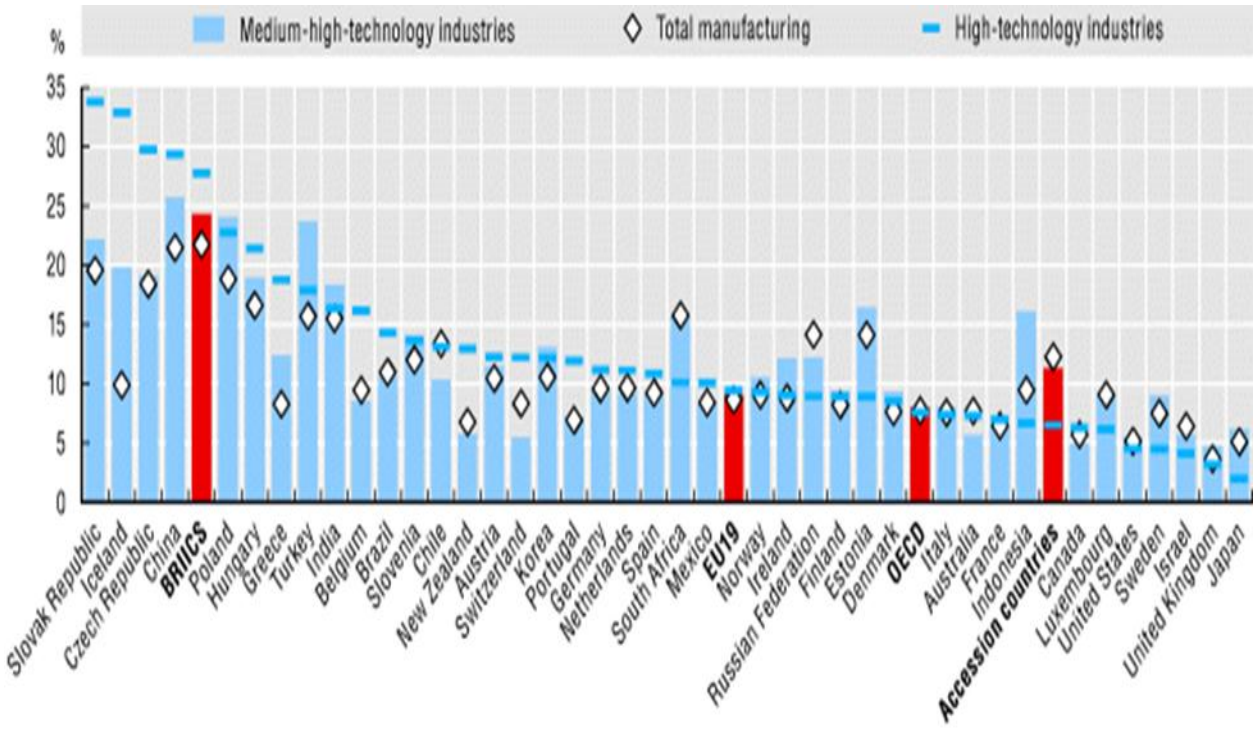

It is innovation that has created global business giants such as Microsoft, Apple, GEC, Siemens, Sony, Nike, Adidas, Virgin and many others. Gerryts and Buys (2008) investigated the relationship between R&D and innovation in South Africa based on data from a South African Innovation Survey conducted in 2001. Their findings propose that South African companies had a comparatively high level of innovation and very low innovation costs and that there is thus scope for development. Their data also revealed a considerable positive link between R&D and innovation. If innovation is utilized in a practical manner it will undoubtedly serve as a major catalyst for development and growth in Southern Africa and beyond. Africa is gradually emerging scientifically onto the global arena despite ascending from a comparatively low base. As South African academics publish more research globally, what is learned in one nation serves as the basis for improvements in other developing nations. Developing nations can perk up their productivity levels by taking up existing technologies or by making gradual improvements in a wide range of other areas. However once the innovation stage of national development is arrived at, more needs to be done to grow productivity. National innovation policies ought to seek to cultivate an environment which promotes entrepreneurship and innovation right across the entire economic spectrum. In this regard, universities in developing nations have decisive roles to play in developing sufficiently distinguishable and effective academic structures. They also need to empower their nations to link with the global knowledge society and compete in the sophisticated knowledge economy (Altbach, 2013). In the current scenario, innovation needs to be rethought as it is posed fresh challenges. In the globalised knowledge-based economy what establishes an innovative performance in the corporate sector has to an extent changed as a result of IT and communication technologies. The Internet has led to the need for new ideas (L S Goh, 2004). South Africa needs to up its game-plan to become competitive since the impact of R&D and innovation on productivity is miniscule by international standards as evidenced in countries such as France, the USA,

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Germany, China, Sweden, New Zealand and Japan (Bassanini and Scarpetta, 2001; de la Fuente and Ciccone, 2002).

Economic development stages

Nations tend to compete based on their natural endowments including natural resources and unskilled and skilled labour. Companies however compete on the basis of competitive prices and the quality of their products and services. To remain competitive a stable macroeconomic framework is imperative and this must be supported by ten basic foundations as listed below:

1. Suitable infrastructure
2. Sound primary, secondary and higher education and training
3. An effective workforce in terms of skills such as literacy and numeracy
4. A healthy workforce
5. Effectively performing public/private institutions
5. Effective use of existing technology
6. Effective processes of production
7. Quality products
8. Strong markets
9. A competitive spirit
10. Innovation and R&D

The key driver of economic development is innovation based on R&D and this must be the product of collaboration between universities and corporations. Entrepreneurship and innovation are critical since the national economy can only be built with novel ideas, as much as with capital provision by both the public and private sectors and effective labour. Innovation, ventures and intellectual assets are what ultimately drive economic growth and lead to increases in the standards of living. Innovation plays a huge role in job creation and provides higher incomes which promote societal development. Where R&D has led to greater innovation, investment opportunities arise, especially from abroad which allow a nation to develop at a greater pace and be positioned to solve more of the problems which plague society.

This is why it is imperative for the government to further incentivize R&D and innovation and guide the process for the protection of intellectual property rights (IPR). The latter play a crucial role in further driving innovation and intensifying information and they also directly impact economic performance and generate economic growth through increased productivity, increased trade and greater levels of investment. Where market failures exist these are to an extent founded on the inability of individuals and companies, to thwart others from making use of the new knowledge they have created. Where there are effective IPR protection measures these serve as a strong incentive which permit companies to invest in generating new technology in a number of sectors without fear that an invention, for example, will be easily imitated.

It is argued that research represents about 25% of the price tag of commercializing a new technology or system and exclusive rights granted to a patent holder for a limited time provide a huge incentive for promoting greater economic support. This permits the

development of ideas to generate a marketable product or technology. IPRs also promote private and public ventures to transfer technology through the development of innovative approaches, direct investment both foreign and local, greater technology sales and distribution and possible other cooperative undertakings leading to a more competitive economy. A competitive economy is one which is more likely to develop faster in the medium to long-term.

The role and needs of universities

The National Plan for Higher Education (NPHE-Ministry of Education, 2001) states in a very specific manner the role of higher education institutions in research and prioritizes that research concentration as well as funding must be linked to outputs and research outputs should be financially incentivized. It also states the number of master's and doctoral level graduate enrolments must increase. Universities need to create learning environments that encourage both academic staff and students to experiment with new ideas. Students should be able to analyse and question information available to them across the various disciplines (Sahlberg, 2009).

By instilling inquisitiveness and promoting inquiry-based, project-based and problem-based learning from the school learning environments and by further promoting this at higher education levels, students are provided with useful information processing techniques. These support students' learning about a wide range of issues of meaning and relevance to them. Such approaches complement technology-rich learning environments that tend to focus on the learning experience rather than on the technologies. Such approaches are most appropriate in both personalised learning and for group work (Underwood, Baguley, Banyard, Coyne, Farrington, Selwood & Selwood, 2007). By promoting appropriate learning environments, students' are inspired about the idea of solving problems or investigating issues.

If the focus is on the learning and the inclusion of relevant technologies in ways that support students to achieve their learning objectives and theu are empowered to conduct research, then innovation and research become part and parcel of the psyche of the students and they are not threatened by the need to conduct research but view it as an exciting challenge. While research is necessary to fuel innovation and national development and economic growth, it is not adequate. The political will to succeed must be strong and there needs to be synergy between academia and industry. In other words, for research to yield practical fruits, the results must enlighten and mould socio-economic policies and be readily adaptable to the needs of society. Innovation is the crux in this regard. University education and training which emphasizes research and innovation is thus the up-and-coming key driver of competitiveness. Human capital endowments in the labour force need to be boosted by employees having accessible new knowledge and they should be able to utilize state-of-the-art technology. Nations such as Israel, which have invested a great deal in creating a well-developed infrastructure for especially higher education have garnered colossal benefits in terms of their development and growth (Lopez-Claros, 2006). Dewey's practical epistemology supplies us with hypotheses which enable intelligent problem solving and does not limit

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research to technical questions but rather highlights the variant understandings of educational reality and diverse ways of viewing the world (Dewey, 1911). Are our research ends always desirable considering the manner in which we can accomplish them or should technical questions be addressed in harmony with a normative, educational and political consideration of what we need. It is clear that South Africa universities reputations and competitiveness are on the increase but they have not yet attained the top echelons of global rankings. They need to become more active partners in the community of global higher education institutions that have shared values and synergies. Universities which drive R&D and innovation should governed centrally with major inputs made by professors who are best positioned to make critical decisions. Research should be infused in teaching and academic freedom should reign as academic staff are empowered not to stick rigidly to daily work hours and be able to engage with the community and broader society. South African universities require adequate and sustained budgets and they cannot hope to succeed if funding is scant. They can however generate income as many students from the rest of Africa are often quite willing to pay higher fees because of the prestige attached to a degree from a South African University. Quality and highly relevant academic offerings that have been benchmarked with the best from abroad, are vital to success.

A South African Chairs Initiative (SARChi) was fashioned to create interventions in the knowledge and human resources base that will hopefully contribute towards helping universities achieve their research strategies. Excellence in research is promoted vigorously and universities may propose current staff members for a number of Research Chairs. The objectives of SARChi are:

• To increase the number of world-class researchers in South Africa;
• To retain or attract qualified research scientists to the higher education sector in order to help reverse the decline in research outputs, focus and capacity;
• To improve the capacity of institutions to generate and apply new knowledge;
• To stimulate strategic research across the knowledge spectrum;
• To create research career pathways for quality young and mid-career researchers that address historical racial, gender and age imbalances; and
• To improve and accelerate the training of highly qualified personnel through research.

Hopefully such initiatives will assist in making the country more competitive in the global knowledge economy but our universities must further commit to the creation and dissemination of knowledge, in a wide range of disciplines and fields, and be supported by, for example, relevant laboratories and libraries etc. that facilitate and promote effective teaching and research which are catalysts for the innovation that is desperately needed to propel us into the future. It should be a top priority to create enabling environments for seasoned and budding researchers in which knowledge production is nurtured and disseminated globally as part and parcel of a relevant and dynamic research culture. Increasing the number of PhD candidates and postdoctoral researchers is essential as is increasing researchers' local and global mobility. Focused education and training in the field of management of research and innovation is thus non-negotiable and universities must drive the implementation of greater research

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capacity via effective development programmes for staff and students alike. Multi, inter and trans-disciplinary collaborative research is desirable since this broadens the knowledge horizon and leads to greater innovation. To be more competitive, research results should be commercialized and the partnership between economic agents and research institutions must be encouraged.

To measure the results of R&D we could consider a number of indicators:

1. How many articles were published in ISI, IBSS, DHET and DOAJ indexed journals or other recognized data bases on the basis of doctoral theses or projects for postdoctoral researchers?

2. How many postdoctoral researchers were financed by research projects?

3. How many participants there were in international conferences and how many of their research endeavours were published in proceedings?

4. How many academic staff and students have attended training courses in the field of management of research and/or innovation?

5. Has a capacity been developed to transfer technology between universities globally?

6. Has there been marked acquisition of external knowledge and financing and are R&D staff collaborating in projects with their peers abroad?

7. Is government allocating additional resources to universities to promote R&D and innovation?

Conclusion

Many scholars attest to the fact that technological innovation and adoption via greater investment in R&D remains a critical conduit to increased growth in especially developing nations. The governments of such nations ought to increase support for R&D in institutions of higher learning, more especially universities as well as in industries. Innovation and R&D explains why high-income countries continue to develop at a rapid pace. Universities play a critical role in supporting the production of knowledge that contributes to higher standards of living and their R&D initiatives are crucial to development. They do however require supportive and effective governmental policies to assist them. South Africa will prosper as a nation because of sound economic policies and institutions that drive R&D and innovation and a government that provides the incentives to utilize resources and technologies to the maximum degree.

South Africa's 23 Universities in particular have a vital role to play in developing nations and they are critical to success in a knowledge-based economy. South Africa has come a long way from the political instability and structural weaknesses which undermined its economy twenty years ago and despite the global economic downturn the nation is on a healthier development path. The national expenditure on research and development

(R&D) is growing and is a key indicator of government and private sector efforts to achieve competitive advantage. Universities need autonomy to shape their programmes and the way in which they practice their craft but there must be a balance between autonomy and accountability.

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