



# The Johannesburg Software Cluster

Finding Digital gold in the 4th Industrial Revolution

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B Chanda, B Mutamba, H Yavuz, J Donald, K Kaneye & N Kuboshima.

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*Picture courtesy of DRD Gold: Removing a 100-year-old mine dump in Johannesburg*

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## List of Acronyms

*African National Congress ANC*

*Brazil, Russia, India, China and South Africa BRICS*

*Cape Innovation and Technology Initiative CiTi*

*City of Johannesburg CoJ*

*Foreign Direct Investment FDI*

*Gauteng City-Region Observatory GCRO*

*General Electric GE*

*Gross Domestic Product GDP*

*HPC-High Performance Computers*

*Human Development Index HDI*

*Information, Communication, Technology ICT*

*Intellectual Property Rights IPR*

*Joburg Centre for Software Engineering JCSE*

*Johannesburg Securities Exchange JSE*

*Key Performance Indicators KPI's*

*Local Economic Development LED*

*Multi National Corporation MNC*

*National Development Plan NDP*

*Non-Governmental Organization NGO*

*Organisation for Economic Co-Operation and Development OECD*

*Public Private Partnership PPP*

*Research and Development R&D*

*Small and Medium Enterprises SME*

*South African National Innovation System SANIS*

*South African State Owned Power Utility ESKOM*

*Special Economic Zones SEZ*

*University of Johannesburg UJ*

*University of the Witwatersrand Wits*

*Venture Capital VC*

*According to Klaus Schwab of the World Economic Forum we are at the dawn of a technological revolution that will change almost every part of our lives – jobs, relationships, economies, industries and entire regions. Johannesburg has seen rapid transformation before, rising as a gold and coal fuelled poster child of electrified production during the 2<sup>nd</sup> industrial revolution only 100 years ago. The high-speed communication and automation of the 3<sup>rd</sup> industrial revolution has turned this ‘city of gold’ into the financial and services hub of Africa. Ever rising prosperity has been accompanied by stark inequality and globally condemned injustice. The so called 4<sup>th</sup> Industrial Revolution brings a blurring of the physical and digital worlds and exponential rates of change. There are opportunities to catch up and fears of being left behind. The City of Johannesburg’s Digital Innovation Precinct can help an underperforming cluster of software firms and related industries form a platform for innovation in the 4<sup>th</sup> industrial revolution. Data is the new gold and software is how it is mined and monetized. South Africa could become a leading exporter of software products and services while deepening its innovation capacity. This will require coordination, commitment and perseverance that has been lacking to date.*

## Executive Summary

The emergence of South Africa's software cluster holds promise because of its rapidly evolving technologies, its strong network into global knowledge flows, and its cross-sector nature, serving all industries and forming as a central innovation driver in the knowledge economy. The software sector is also a tradable sector meaning that, if local firms are competitive, they can generate substantial network effects on the South African economy whose growth enablers rank among the best in Africa. South Africa has a small but highly skilled software industry and a relatively high rate of investment in the information, technology and communication sector (Fredriksson et al. 2012). Local government and international experts have tried for the last decade to translate these ingredients into a more robust software export industry. While no such boom has materialised, an emerging software cluster in Johannesburg has the potential to change the growth trajectory of the local industry. The intensely integrated innovation systems required for such an industry have been missing in South Africa. In Israel, this innovation system is led by the state through the Ministry of Defence, while in India and the United States it has emerged from a thriving business outsourcing sector and large scale investments in human engineering capacity in the education sector. South Africa has similar inputs but too small a scale. Recently, however, Johannesburg's large domestic market, and advanced financial sector and outlook as Africa's business and technology hub have caused an emerging creative energy in software and technology development. We analyse this software cluster and explore its potential to serve as a platform for a regional innovation ecosystem.

Over 90% of world data was generated in the last two years, and software development can be understood as the process of extracting ideas from exploding sources of information to be applied in practical ways to solve problems, either for governments, civil society or the market. This is the traditional flow of scientific exploration to technological innovation to entrepreneurial application, accelerated. The recommendations expressed under this analysis are premised on the need for the government to allocate substantial financial resources for the software cluster development in Johannesburg. Improving the business environment to attract foreign direct investment and spur local entrepreneurship in the sector is key in harnessing the existing agglomeration effects of key economic sectors in Johannesburg e.g. mining, finance, tourism and the air industry. Our recommendations also point to the need for investment in infrastructure in as far as it relates to improving the generation of energy which is a key input to the growth of the software sector. Another important piece is the need for the government to enhance its efforts of developing a strong human capital base that supports the software sector by broadly based investing in Science, Technology, Engineering and Maths (STEM) through curriculum development, improvements in the quality of teacher training, increasing internet access to learning institutions to ensure continuous access to cutting-edge software technology and expanding the capacity of institutions of higher learning to absorb more students geared towards STEM. These are among the important areas of improvement for the development of the software cluster in line with the city of Johannesburg's ambitions.

## 1. Context

### 1.1. Socio-Economic Trends

In socioeconomic terms, South Africa is classified as a middle-income emerging market with an estimated GDP income of \$20.493 trillion largely driven by trade (62.8% of GDP) (**World Bank**). South Africa is the second largest economy in Africa, contributing approximately 15% of the continent's GDP and is also closely integrated with the global economy. Between 2000 and 2014, real GDP grew at 3.1% per annum under the country's key economic sectors i.e. Tourism, Mining, Automotive Assembly, ICT and Chemical Industries. Other contributing sectors to the economy include Finance, Legal, Communications, Energy and Transport. These sectors have provided a basis for the emergence of the software industry in line with the analysis of this paper. In 2011, the country's Gross national income (GNI) per capita (PPP\$) stood at \$12,087 (**Human Development Report 2016**) which is comparatively higher than most African countries but lies within the same range as Mauritius and Botswana. In 2017, South Africa's economy stalled. Flat growth, low commodity prices and inflationary pressure added to a fragile political climate where uncertainty in economic policy has brought about rating downgrades. There is however sustained interest in South Africa as a large domestic market and a gateway to Africa. The country currently ranks 100 out of 189 countries in the ease of trading across borders and is among the top 5 performers in Sub-Saharan Africa (**Doing Business 2015**). Lowering barriers to entry for all businesses, large and small, has been central to Johannesburg's economic development strategy.

### 1.2. Factor Endowments

South Africa is one of the wealthiest countries in Africa. This is complemented by the country's factor endowments which include fertile land, mineral resources (discovered in the 1800s leading to white settlement) and good climatic conditions. A distinctive characteristic of South Africa is that it is the world's fifth-biggest mining sector in terms of GDP. Approximately, 93% of South

Africa's minerals are found in Gauteng province where Johannesburg is located. The significance of the South Africa's mining sector is its contribution to the country's GDP at 8.6% as well as its employment absorptive capacity which currently stands at over half a million people. The backdrop of South Africa's economic growth includes notable factor endowment such as a landmass totalling **1,219,090 Sq. Km** bound by the Atlantic and Indian Oceans on either side of the country as well as fertile arable land. South Africa shares its borders with six relatively stable countries (**CIA World Factbook, 2017**). South Africa's location, in the southernmost tip of the African continent, in addition to its strong standing in economic growth and dual entrepôts, makes it a competitive industrial and service hub. This is augmented by the country's well-developed infrastructure, financial and legal systems, communication grid and networks, as well as its energy and transport sectors. Notably, South Africa is home to the Johannesburg Stock Exchange (JSE) which is Africa's largest stock exchange and among the top 20 in the world. These growth enablers provide forward linkages to the country's software sector. Further, South Africa's geographical position gives it a competitive edge. The country's access to both the Atlantic and Indian oceans connects it to main trading routes in Africa and other countries in Europe, North America and Asia. The location factor is further augmented by the undersea cabling, which has accorded South Africa terrestrial cross-border fibre optic connection with 52 African countries that are currently connected to the submarine cables (Africa Bandwidth Maps). (Ref Exhibit 1).

This present-day connectivity is built on South Africa's historical importance in global gold production and the formation of a regional minerals and energy complex centred around Johannesburg.

### 1.3. Population and Labour Market Analysis

South Africa is home to a diverse mix of people (Black, White, Mixed and Asian) with an estimated population of 55 million people (49% Male & 51% female) (Source IMF 2016). Like



most African nations, the country has a large youth population (69% below the age of 35; 18.5% between the age of 10-19 and 24% between the age of 15-24) (**UNFPA South Africa**). Approximately 64.3% of the population resides in urban areas (**World Bank 2015**). South Africa's labour force is estimated at 21.7 million people and is primarily engaged in agriculture (4%), industry (18%) and services (66%) (2014 est.). In 2016, South Africa's unemployment rate was estimated at 26.8% constituting a 1.4% rise from the 2015 estimate of 25.4%. This analysis indicates the stubbornly high levels of unemployment in which, 1 in 4 South Africans is without a job. The situation is even worse among the youth in which, 1 in 2 is unemployed. (<http://www.doingbusiness.org/~media/WBG/DoingBusiness/Documents/Subnational-Reports/DB15-South-Africa.pdf>). In 2012, the population living below the poverty line was estimated at 35.9% (**CIA Factbook**), and the Human Development Index (HDI) stood at 0.666 in 2015 placing the country in the medium human development category (i.e. 119 out of 188 countries and territories) (**HDR 2016**). Unfortunately, employment has not risen fast enough to absorb the strongly expanding labour supply and reap the demographic dividend, and unemployment has been chronically high (**OECD**). Recent efforts to reform the labour market have focused on the introduction of a national minimum wage (NMW) ("**Mission Concluding Statement.**" **South Africa: Accessed April 12, 2017**).

#### 1.4. Macro Challenges

While the opportunities in South Africa abound, economic growth has decelerated in recent years. Even though the country's modern infrastructure supports a relatively efficient distribution of goods to major urban centres throughout the region, unstable electricity supplies retard growth. South Africa's economic policy has focused on controlling inflation; however, the country faces structural constraints that also limit economic growth, such as skills shortages, declining global competitiveness, and frequent work stoppages due to strike action. The current government faces

growing pressure from urban constituencies to improve the delivery of essential services to low-income areas and to increase job growth. (CIA Fact Book, 2017).

## 2. Provincial to City Landscape and Institutions

### 2.1. Gauteng and Johannesburg

Gauteng province is one of nine provinces in South Africa created by the African National Congress (ANC) government at the end of the apartheid era. It was carved out of the old Transvaal province on April 27, and was renamed Gauteng, Sotho word for gold/place of gold in December 1994. Gauteng is located in a mineral-rich region that had placed it at the centre of the global trade in diamond and gold, since 1867/1886, when diamonds and gold were discovered in the region. The early discovery of minerals also gave the province a competitive advantage over other regions to position itself as the country's industrial, financial and technological centre. It is the smallest and only landlocked Province in South Africa but endowed with a well-developed infrastructure system including roads, railways, and airports. The region has 28 small airports, six regional airports, one international airport (Oliver Tambo) and one Helicopter strip. Metrorail, a network of commuter rail services in Gauteng province connects most suburbs of greater Johannesburg metropolitan and Pretoria. Gauteng is home to two of South Africa's main cities, Pretoria the administrative capital city & Johannesburg the biggest city, and one of the 50 most urban areas globally. Gauteng occupies 1.4% of South Africa's land mass and contributes about 34% to the country's GDP, about 42% SA's industrial output & over 10% of Africa's GDP (Gauteng Provincial Government). Gauteng province's economy is estimated to be 1.07 Trillion Rands, which makes it SA's main economic hub. (Gautengonline.gov.za). The province has a vibrant tourism sector that includes theatres, museums, and national parks and good academic institutions that attract thousands of students from across Africa annually. A Brookings Institute Report compared the Gauteng City Region (GCR) with eight global peers such as the so-called 'gateway cities' of

Istanbul, Mexico City and Shenzhen (Parilla & Trujillo, 2015). The report labelled the GCR the powerhouse of African business and pointed to the high presence of multinational corporation headquarters as evidence of similar gateway status. While the authors identified innovation as a relative strength with industry and university collaboration, they warned that declining patent filing rates and an under-investment in venture capital should be noted and acted upon. The South African National Innovation System (SANIS) was conceptually sound but poorly integrated with the efforts of Johannesburg, the nation's economic engine (Raphasha 2015). Emerging from this vibrant province is the city of Johannesburg. The city has 4.64 Million residents with a per capita income of \$ 7000 per year. Colonial and apartheid land use and subsequent underinvestment in housing means that poverty is concentrated in densely populated areas spatially, or socially, removed from employment. Low wages and poor education contribute to this situation as well as socio-political factors i.e. urbanisation, immigration, segregation and economic forces i.e. splintered urbanism, urban sprawl, the transition to a service economy continue to exacerbate current conditions.

## 2.2. Institutions Supporting Software Development

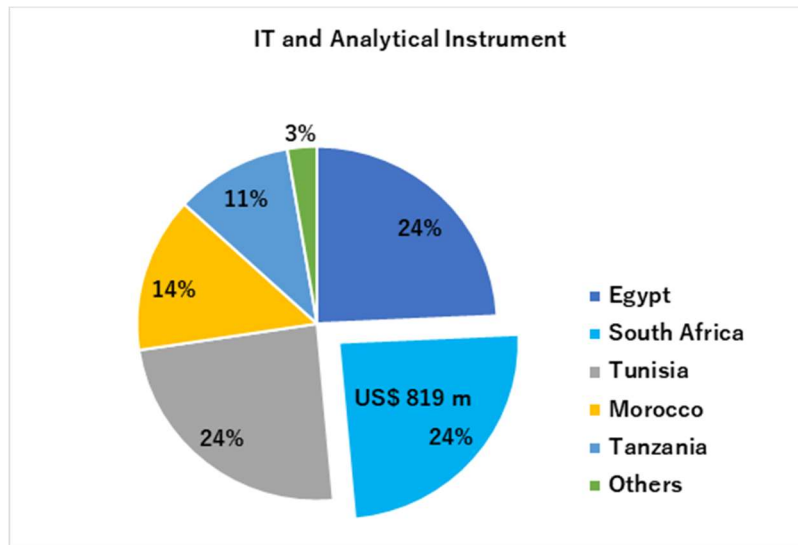
In response to the unique history of this significant agglomeration, which is anchored in Johannesburg, was the creation of the Gauteng City-Region Observatory (GCRO), a research partnership between the Gauteng Provincial Government and the Universities of the Witwatersrand (Wits) and Johannesburg (UJ) (Mubiwa and Annegarn, 2013). The GCRO improved the integrating capacity of local government by, for example, commissioning an interactive GIS system from the Johannesburg Centre for Software Engineering (JCSE), a partnership between Wits and the CoJ (JCSE, 2015). The JCSE partnership was extended in 2016 to create the Tshimologong Digital Innovation District, a technology hub in Johannesburg, that used corporate tax rate credits to attract firms and encourage the growth of Johannesburg's software

cluster in a district of the inner city that has been experiencing urban renewal. Early investors included an IBM research laboratory and the innovation offices of provincial government agencies such as Treasury (e-government services Design and Validation Services) and The Innovation Hub (South Africa's only accredited innovation centre). The World Bank reported that Johannesburg hosted three digital technology hubs, including venture capital lead hubs in the Fintech environment (Anon n.d.).

### 3. Trade Share and Business Environment of Software

The top 3 world exporters of "information technology and analytical instruments" in 2015 (latest available data) were China, Singapore and Taiwan. The total value was \$375 billion, \$114 billion, and \$99 billion respectively. China's share alone comprised 27% of world exports in value, whereas South Africa's exports value of the total share was \$819 million i.e. 0.06% (Bryden, R). On the other hand, the world's top 3 exporters of "computer and communication services (including software)" in 2015 were Ireland, India and Netherland whose export values were \$63 billion, \$58 billion, and \$43 billion respectively. South Africa's exports value of this was \$572 million, and its share was 0.13% reflecting the countries viability in engaging in the sector. In Africa alone, the presence of South Africa's IT industries is significant. **Exhibit 1** shows the export share of "information technology and analytical instruments" among 29 African countries derived from available data in which South Africa is the 2nd largest exporter (\$819 million), which comprise 24% of Africa's total. Further, **Exhibit 2** shows that South Africa is the top 1 exporter of computer and communication services totalling \$572 million in value i.e. a share of 74% out of available data collected from 8 African countries.

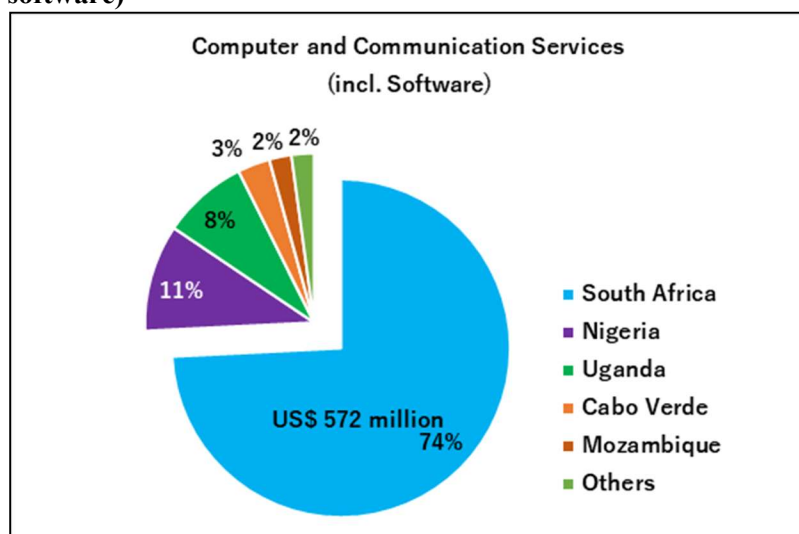
**Exhibit 1. Export share of IT and analytical instruments among African countries**



Source: Derived from "International Cluster Competitiveness Profiles"  
[http://www.richbryden.com/iccp/cluster\\_values.html](http://www.richbryden.com/iccp/cluster_values.html)

Although South Africa's world share is still relatively small, and relative importance of software trade in South Africa is quite minute (merely 0.52% of total trade volume), there is clear evidence that Software, which falls within the “computer and communication services” and complementary clusters such as ICT equipment industry is significant in Africa. According to the 2015 Competitiveness Index, South Africa's national business environment is ranked 33rd out of 68 surveyed countries. To analyse the quality of the national business climate and competitiveness issues, we summarised top-ranked indicators, poorly ranked indicators and indicators seem to be related to software cluster in **Exhibit 3**.

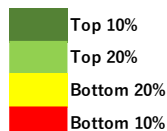
**Exhibit 2. Export share of computer and communication services among African countries (including software)**



Source: "International Cluster Competitiveness Profiles" [http://www.richbryden.com/iccp/cluster\\_values.html](http://www.richbryden.com/iccp/cluster_values.html)

**Exhibit 3. South Africa's national business environment (shown in the rank out of 68 countries)**

Factor (input) conditions	36	Demand conditions	46
Logistical infrastructure	42	Government procurement of advanced technology products	58
Quality of air transport infrastructure	13	Government success in ICT promotion	59
Quality of electricity supply	65	Laws relating to ICT	34
Quality of domestic transport network: business	56	<b>Supporting and related industries and clusters</b>	<b>31</b>
<i>Communications infrastructure</i>	<i>52</i>	Availability of latest technologies	35
Mobile telephone subscribers per 100 population	8	<b>Context for strategy and rivalry</b>	<b>27</b>
Internet access in schools	63	Strength of auditing and reporting standards	1
Percentage of households with computer	56	Effectiveness of antitrust policy	8
Telephone lines per 100 population	59	Cooperation in labor-employer relations	68
<i>Administrative infrastructure</i>	<i>49</i>	Pay and productivity	57
Doing Business, Paying Taxes (Low) Payments number	7	Intellectual property protection	21
(Low) Time required to start a business	63	Efficacy of corporate boards	1
<i>Capital market infrastructure</i>	<i>8</i>	Strength of investor protection	11
Regulation of securities exchanges	4		
Soundness of banks	6		
Financing through local equity market	1		
Protection of minority shareholders' interests	1		
Domestic credit to private sector	12		
<i>Innovation infrastructure</i>	<i>52</i>		
Quality of the educational system	67		
Quality of math and science education	68		
Availability of scientists and engineers	61		
Tertiary enrollment	62		

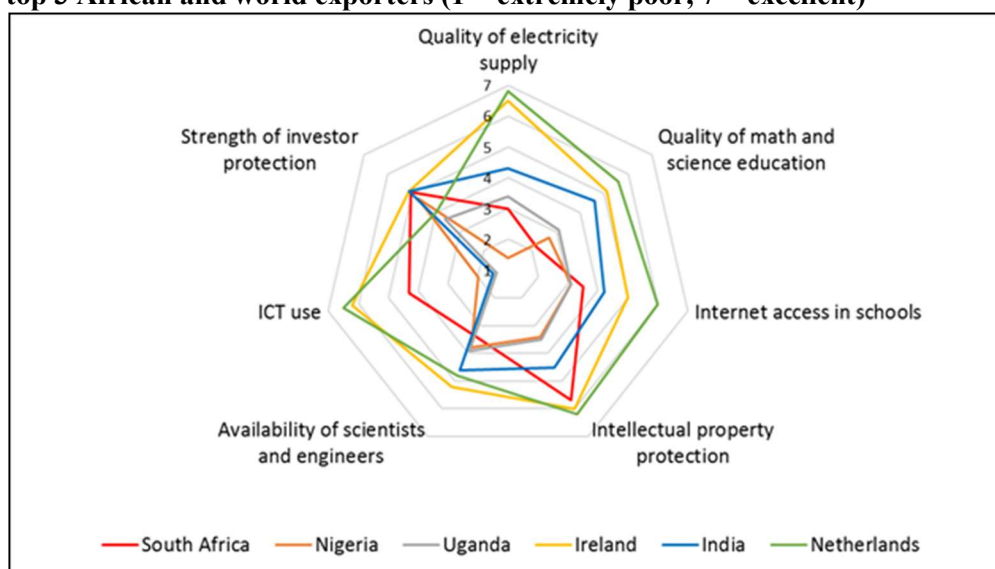


Source: Institute for Strategy and Competitiveness, Harvard Business School Competitiveness Index 2015

There are three main concerns related to the growth and competitiveness of South Africa's software sector. Firstly, electricity supply, which is an essential input to software development is insufficient (65th/ 68). Secondly, the country's "innovation infrastructure" is quite inadequate (52nd/ 68) due to the unsatisfactory quality of education system (67th) viz math and science education is at the bottom (68th) In addition, both primary and tertiary enrolment is low (62nd) (though secondary enrolment is world top class as ranked 1st). This translates to a challenge in the availability of scientists and engineers (61st) resulting in the reliance on foreign-trained software engineers. Thirdly, communication infrastructure is also insufficient (52nd). Internet access to schools is scarce (63rd). This limits continuous access to cutting-edge software technology through the internet. The percentage of households with computers is ranked 56th in the world. However, mobile telephone subscriber rates fairs well (8th) implying that people are exposed to internet technology through cell phones and the market for related application software may be bigger than that of computer software. Other indicators directly related to software cluster include "laws relating to ICT" and in particular Intellectual Property Rights (IPR), are essential for maintaining incentives for companies to invest in Research and Development (R&D). South Africa ranks (21st) in intellectual property protection. Currently, companies seek approval from the Reserve Bank for their intellectual property transaction. This is to protect intellectual property from draining to foreign countries where lower tax rates are posted. The National Treasury is making efforts to relax the restriction on the ownership transaction by lifting the approval process (National Treasury, Republic of South Africa). This easing business procedure is a positive move for attracting investment.

**Exhibit 4** compares the national business environment indicators related to software industries among 3 top African computer and communication services exporters i.e. South Africa, Nigeria and Uganda and the 3 top world exporters i.e. Ireland, India, and Netherlands. Some of South Africa's software related business environment indicators are competitive when compared with global leaders in this sector. South Africa's investor protection, intellectual property protection and ICT use actually have better ratings than lead countries in this area.

**Exhibit 4: Comparison of software industry related business environment among top 3 African and world exporters (1 = extremely poor, 7 = excellent)**



Source: Derived from "World Economic Forum, Global Competitiveness Index

#### 4. Gauteng Province' Growth Strategy

Gauteng's provincial government is aware of the weakness, and the challenges related to the growth of the software cluster and actions to address this are incorporated in the "Transformation, Modernization and Reindustrialization of The Gauteng City-Region: 2015-2030". One of the pillars of the strategy aims to "accelerate social transformation" and address education, health and community safety. In education, as it relates to software development, the emphasis is placed on mathematics and science technology education including improving teacher quality, and

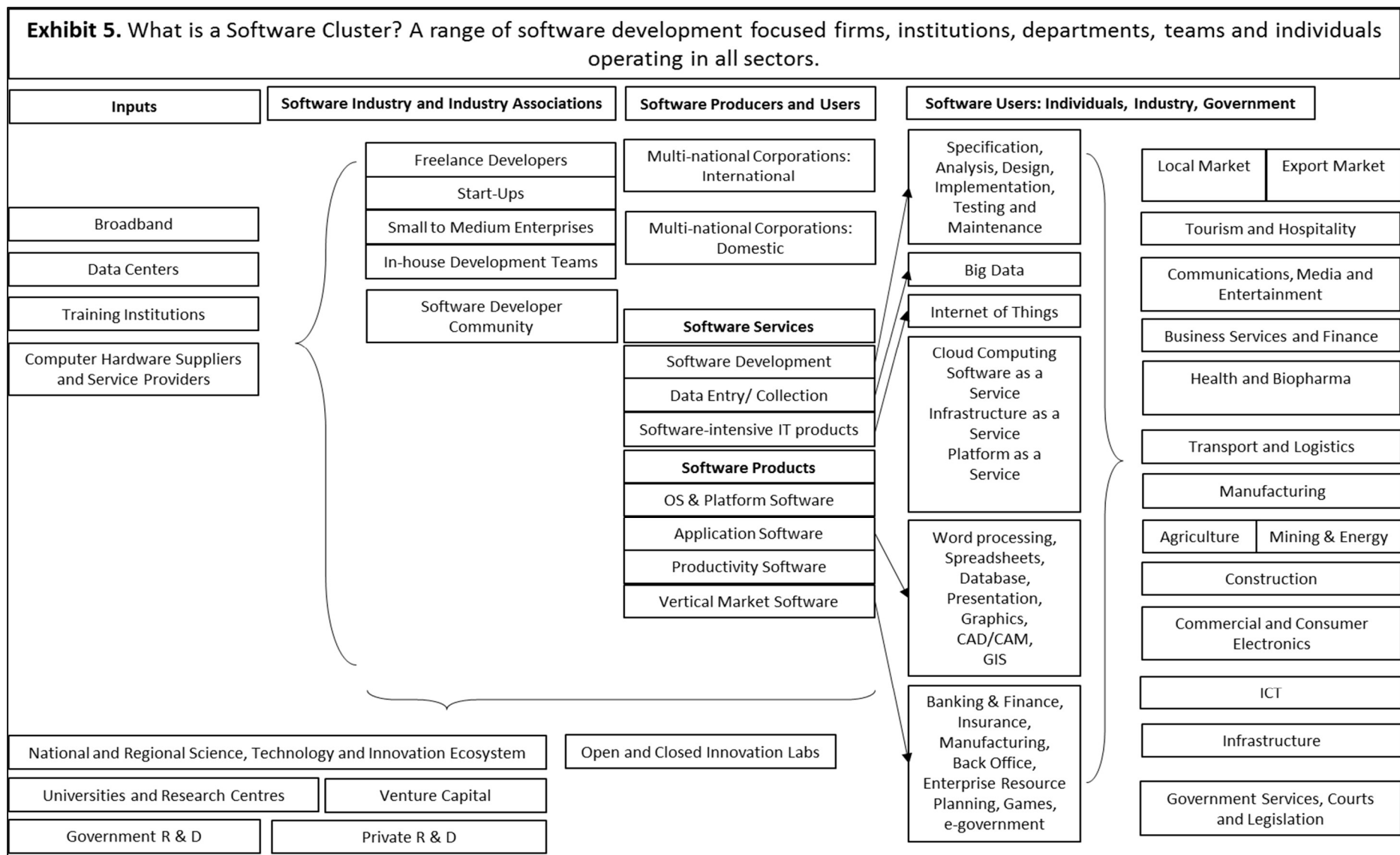


curriculum upgrade. Under the strategic pillar of “Modernization of the Public Service ” Gauteng’s vision is to expand access to e-government by harnessing ICT and expand free Wi-Fi and the broadband network to all key economic zones as well as education facilities. The introduction of "smart schools" (e-learning and electronic reporting systems) is also planned as well as the establishment of Special Economic Zone (SEZ) for ICT in Gauteng. To address the country’s persistent energy challenges, the province plans to increase generation capacity by 1,200MW through coal-fired power plants, installation of waste-to-energy generation, and solar manufacturing farms in partnership with higher education institutions.

## 5. Johannesburg’s Software Cluster

Gauteng’s Growth Strategy uses Cluster Theory to identify firms and sectors that are interconnected in their field and linked by external economies of commonalities and complementarities. Software has become both a sector and a key input into production across sectors. **Exhibit 5** shows the multiple components and relationships of the software cluster in Johannesburg. The Johannesburg Centre for Software Engineering currently attempts to coordinate efforts to increase productivity and operational efficiency, stimulate and enable innovation and facilitate commercialization and new business formation. We propose that as a first step in energising the cluster the JCSE be tasked with converting the cluster map into a work plan committing key players to perform the central tasks of cluster development. According to Porter & Delgado et al. 2016) such activities are most likely to improve local competitiveness by.

- Providing efficient access to the specialized goods, services, talent and information required by the software industry
- Coordinating and rapidly diffusing best practices
- Provide visible performance comparisons and strong incentives for firms to improve or differentiate
- Improve the recognition of innovation opportunities and support experimentation
- Make opportunities for new companies or new lines of business apparent
- Encourage spinoffs and start-ups by concentrating demand
- Improve available skills and supplies to make commercialising new products easier.

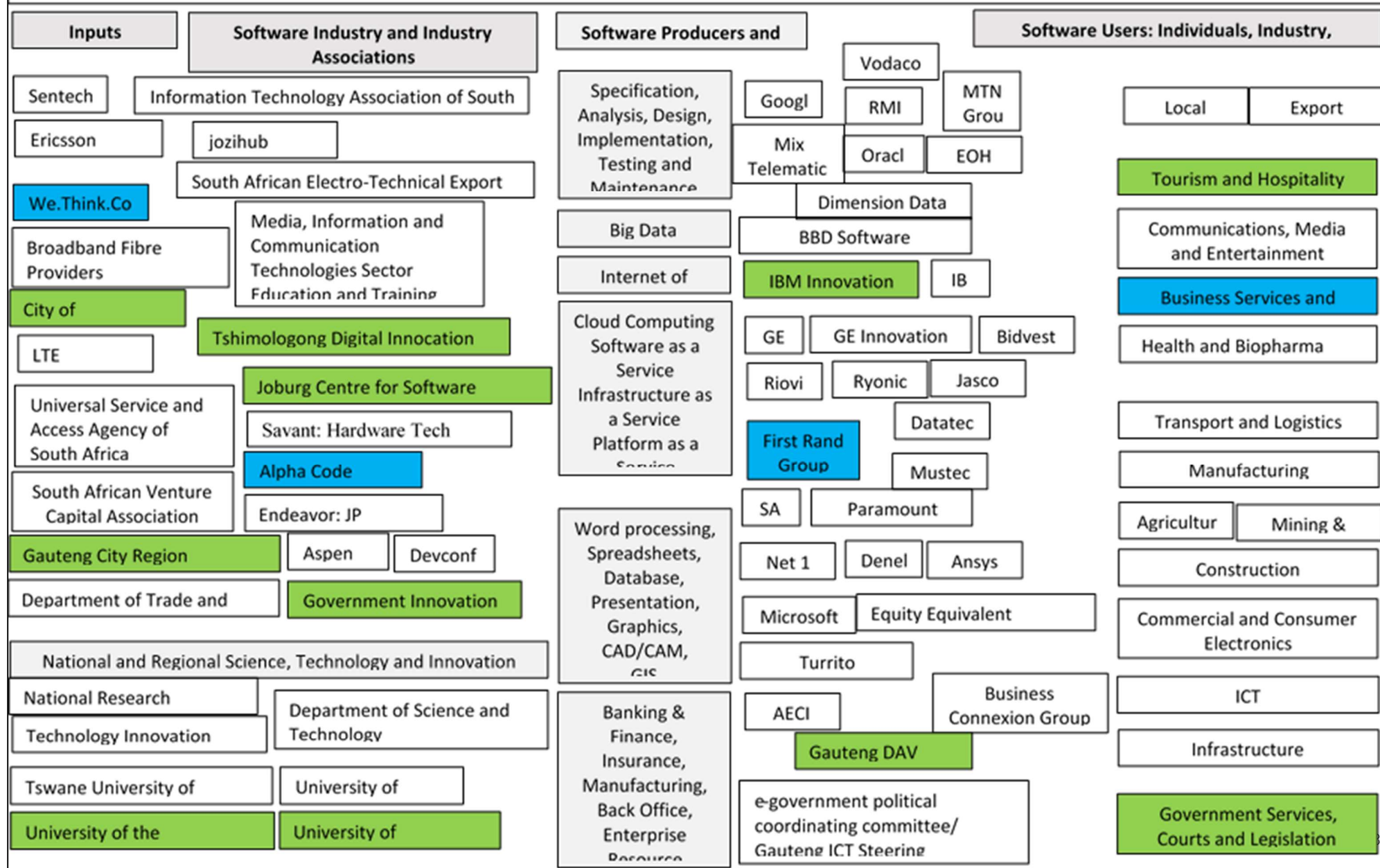


Modified by J. Donald from the UNCTAD, Information Economy Report 2012

## 5.1 Historical Development

Johannesburg's software industry is old and well established though it has arguably not operated as an efficient cluster. In 1999, the Canadian Government funded a comprehensive KPMG study of the South African IT sector. The study found that the established industry had a strong skill base but that it was too small and that it had developed in isolation under apartheid-era which meant that international best practice in the sector had not diffused into local systems. While some local software multinational companies had emerged from the country, many were not competitive internationally. The report recommended that national government take a strategic focus in the software sector given its potential to grow. By 2004, however, the government's efforts were still disjointed, and a Professor Barry Dwalotsky of the Computer Science Department at the University of the Witwatersrand decided to take an active role in advancing an improvement agenda in the industry. In partnership with the City of Johannesburg, Wits created the Johannesburg Centre for Software Engineering (JCSE). From inception Professor, Dwalotsky believed Johannesburg, and Braamfontein, in particular, had the ingredients for a successful software cluster. Professor Dwalotsky followed the writings of Professor Michael Porter and thought of Cambridge's Kendall Square as an example of the environment that the software cluster could thrive in. The criteria he laid for the development of a software cluster included: 1. Proximity to a respected international research university 2. Proximity to existing businesses 3. Existing infrastructure 4. Connectivity: Transport and Fibre Optics 5. Life style 6. Government policy and support; but not direct government leadership. As of 2017 the JCSE has become the heart of the City of Johannesburg's Tshimologong Digital Innovation District and Johannesburg's Software Industry is catching up with Cape Town's start-up culture. **Exhibit 6** highlights emerging themes in the government services and financial technology services sector in Johannesburg.

**Exhibit 6. Johannesburg's Software Cluster:** Technological trends (4<sup>th</sup> IR) and growth in investments (esp. fintech) are being supported by joint private action to improve the business environment. Emergent cluster properties in start-up,



## 5.2 Current State Analysis

Our analysis of the data is that the case for the software cluster development in South Africa is hopeful; if not yet compelling. South Africa's software export sector has significant nascent potential. The scale and relative percentage of ICT investment coupled with growing demand make the South African innovation system a likely candidate to produce globally competitive software platforms and products. This has been evident for at least ten years, but the Johannesburg software cluster seems to finally be coalescing into an environment that could see fast growth. The first trend we notice is the spike in interest in the Johannesburg Centre for Software Engineering (JCSE). A small but ambitious network of start-ups are growing out of the JCSE as Braamfontein starts to mirror the gritty creative class spark that we've seen in places like Shoreditch and Silicon Valley. A significant investment by IBM, practical support from government technology agencies through innovation labs and validation centres and a city of Johannesburg supported Digital Innovation district seem to indicate that the JCSE's time has come. We believe that the JCSE is the de facto cluster coordinating organisation and that its role should be elevated and supported. The second trend is a related interest in innovation labs from international Multi-National Corporations (MNC's). In addition to IBM's laboratory, Microsoft and General Electric (GE) have begun to invest in local innovation capacity and actively pursued open innovation strategies by supporting hackathon and engaging smaller firms in collaborative, rather than competitive ways. This seems to be a change in focus, partly fuelled by their internal demand for suppliers and supply chains and governance and SA's legal pressure to reach black economic and sector transformation goals. Thirdly the finance sector, itself an aggressive innovator in software platforms for local needs over the last ten years, has expended its view into fintech and start-up support.

Local tech hubs have grown and faded over time but the emergence of Alpha Code, a VC styled incubator lead by a major local player and with broad international backing, is shifting start-ups from the world of bootstrappers and Mavericks into serious investment.

Fourth is a rapid diversification of interest and skill in the profession and practice of coding. World class institution like WeThinkCode is tapping into the vast pool of urban youth Johannesburg generates year after year and the emergence of talent from poor neighbourhoods is bringing an aspirational energy that will give Johannesburg a unique edge. Johannesburg's spatial inefficiencies are crippling, apartheid planning and subsequent free market-driven urban sprawl mean over 70% of Johannesburg's resident live on isolated and segregated parts of the city, spending over 40% of their income on transport to and from work and economic opportunity (Kaziboni et al. 2015). A transit orientated development plan in the City of Johannesburg, called Corridors of Freedom, hopes to transform this shape over time while entrepreneurial hubs and township economic development initiative of Gauteng Province work to spark growth in these isolated hubs.

### 5.3. Johannesburg Software Cluster Diamond (Business Environment) Analysis

Analysing the strengths and weaknesses of the business environment is a major step to understanding the needs of the cluster to develop further and also to come up with applicable and efficient recommendations. In **Exhibit 7**, the factors with a check sign indicate strengths of the business environment that cluster participants can continue to build on. The minus signs show the weaknesses of the business environment that require both the public and private sector to work on since they weaken the current position of the cluster and can prevent its further development.

Johannesburg has several factor conditions that make software businesses well positioned for success and attract foreign investment. First, some big multinational software companies have their

African headquarters in Johannesburg such as IBM, Microsoft and Cisco. The location of the software companies influences their development. The firms located to dominant software companies tend to develop products largely build on or support the dominant firms. In this way, the small businesses have the chance to position themselves within the value chain of the big companies. Microsoft and GE, for example, have active supply chain investment programs in Johannesburg that are also used to meet economic empowerment charter's and requirements.

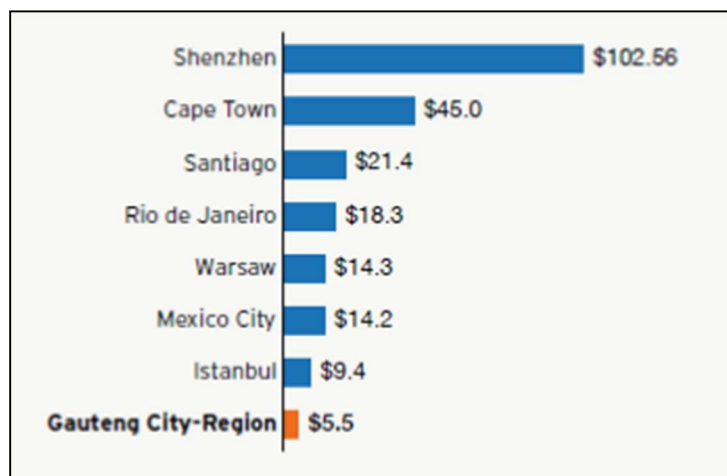
## Exhibit 7. Outline of the Quality of the Johannesburg Business Environment for the Software Cluster

Factor (Input) Conditions	Context for Firm Strategy and Rivalry	Demand Conditions
<ul style="list-style-type: none"> <li>✓ High quality but small advance developer skill base</li> <li>✓ Attractive to expat talent but challenging work permit process</li> <li>✓ Active local Venture Capital</li> <li>✓ Active Regional and National Development Capital Environment</li> <li>✓ Growing Foreign Direct Investment in the sector but recent investment status downgrades may impact risk appetite</li> <li>✓ Strong infrastructure and increasing Wi-Fi speeds               <ul style="list-style-type: none"> <li>– Electricity supply has been unstable but seems to be improving</li> </ul> </li> <li>– Strong local research universities and R &amp; D facilities but declining numbers of local patent registration is a concern.</li> <li>– Unstable political environment</li> </ul>	<ul style="list-style-type: none"> <li>✓ Broad Based Black Economic Empowerment Incentives</li> <li>✓ King VI Corporate Governance Standards</li> <li>✓ Highly active competition commission</li> <li>✓ Thick market of local and international companies</li> <li>✓ MNC's Africa HQ's in Johannesburg</li> <li>✓ Johannesburg culture of openness and diversity in a hardworking business environment</li> <li>✓ Strong IP protection               <ul style="list-style-type: none"> <li>– Some negative sentiment on IP related processes. IP owned by local companies is impacted by reporting requirements that deter investors.</li> </ul> </li> </ul> <div data-bbox="798 935 1295 1013">Related and Supporting Industries</div> <ul style="list-style-type: none"> <li>✓ High quality imported and locally produced supporting industries in mining, finance, business services and manufacturing, particularly vehicle manufacturing.</li> <li>✓ South Africa however does not have a developed electronics industry.</li> <li>✓ Local venture capital investment               <ul style="list-style-type: none"> <li>– IT infrastructure is improving but still lower than the world average</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>✓ Strong industry associations and presence of multinational firms</li> <li>✓ Renewed government interest in improving the innovation ecosystem for technological product and process development</li> <li>✓ South African Bureaus of Standards and ISO 9001 industry commitments</li> <li>✓ Growing Business Process Outsourcing Industry</li> <li>✓ Strong presence of open innovation labs from multinationals</li> <li>✓ Strong government procurement demand</li> <li>✓ Strong Financial Sector Demand</li> <li>✓ Mining and automotive manufacturing</li> <li>✓ Fintech innovation clubs</li> <li>✓ Tech collab. and maker spaces</li> <li>✓ Mining robotics</li> <li>✓ Growth in interest and diffusion of technology in:               <ul style="list-style-type: none"> <li>• Server/ Cloud computing hosting</li> <li>• Internet of Things/ Smart Cities</li> <li>• Consumer web and smart phone applications</li> <li>• Locally developed platforms</li> <li>• Growing fiber and LTE connectivity</li> </ul> </li> <li>– Focus on Domestic Market</li> <li>– Deindustrialization</li> </ul>



The existence of globally dominant MNC's in the city attracts other foreign big businesses and help the development of local and relatively smaller firms though attractive corporate career paths may have a suppressing effect on local entrepreneurship. The second significant strength of the cluster is that it has the support and interest of the provincial government, which evidently understands the importance of the sector. In 2012, the Department of Economic Development of the Gauteng Province published the "Gauteng Innovation and Knowledge Economy Strategy". The evaluations in the document showed the government's willingness to analyse the obstacles to the IT sector, innovation and R&D and its intentions to take concrete actions. In this paper, the importance of collaboration between government-university-NGO-industry collaboration is stressed. As alluded to earlier, the creation of Tshimologong Precinct, JCSE and their link to Wits University shows that the government supports the emergence of the software cluster in Johannesburg. The existence of Venture Capital (VC) is an important asset for the cluster because it provides funds for innovative enterprises positioned for high growth with the potential to create and capture entire new markets. VC recipients are three to four times more patent-intensive than other firms and are much more likely to translate their R&D activities into high-growth ventures. Although venture capital has been increasing with foreign investments and domestic funds in the region, Johannesburg needs to improve to fully capture the benefits of venture capital. The software sector provides the second larger source (30%) of all the venture capital invested in the region between 2005 and 2014. **Exhibit 8** compares the Gauteng region with some of its global competitors.

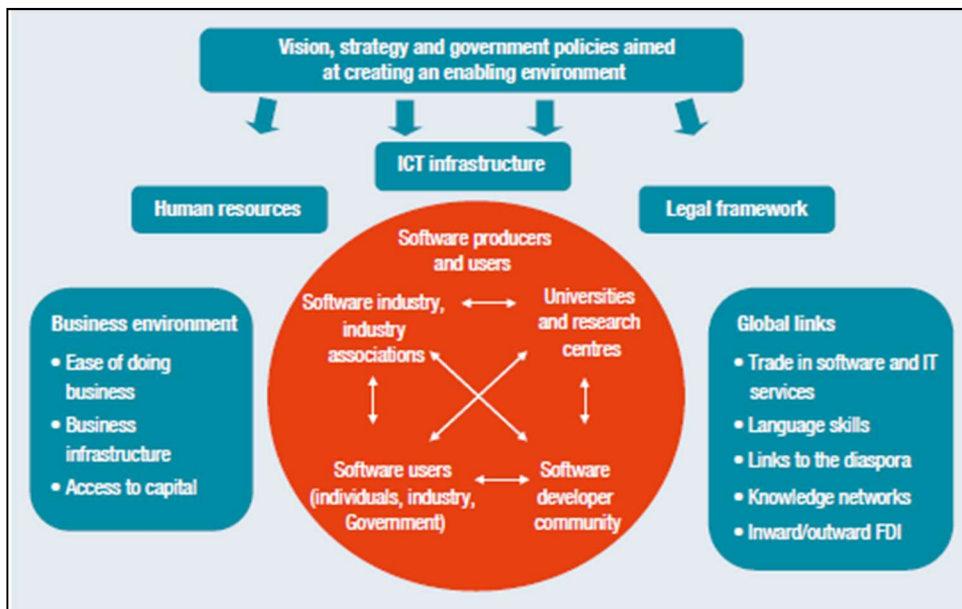
**Exhibit 8. Total venture capital investments, USD millions per 1,000 inhabitants, 2005-2015**



Source: Brookings analysis of Pitchbook data and SAVCA data. (Graph taken from Parilla J., Trujillo, J. L., 2015)

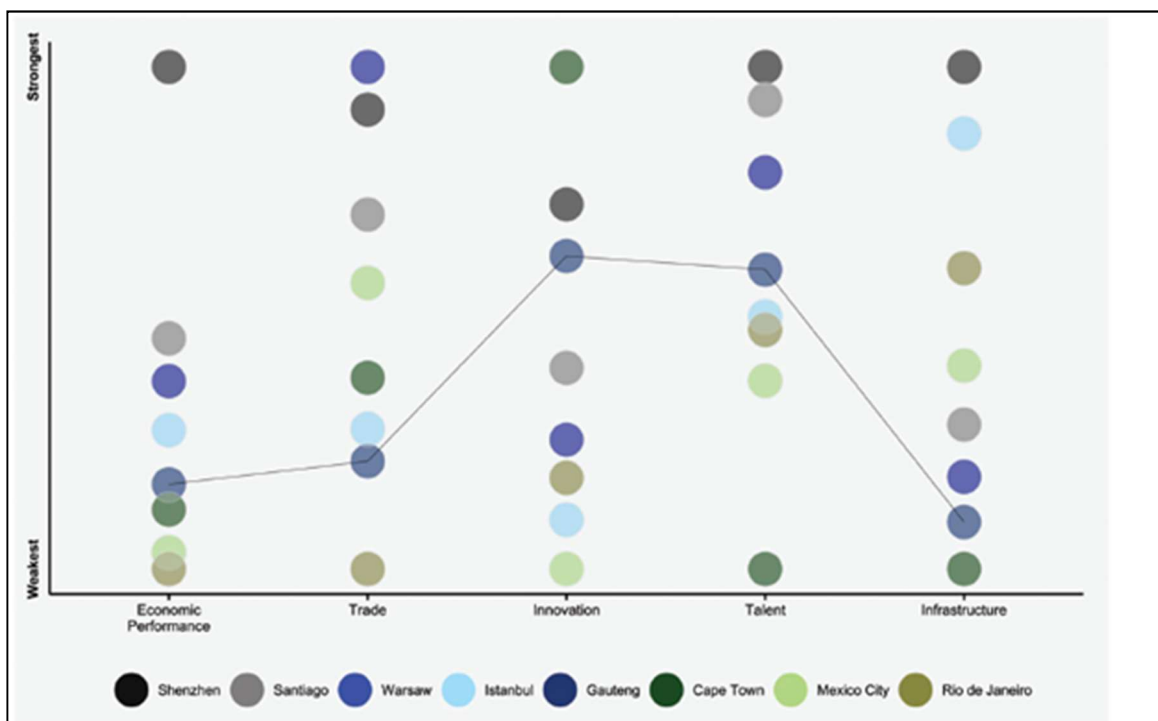
Factor conditions that hinder the competitiveness of the cluster include a lack of human capital on this industry which relies heavily on engineering skills. Although the South African government is trying to increase the number of universities that respond to the software clusters development, it must invest in increasing the quality and capacity of the universities to produce skilled workers that can work directly in the software industry. Only 300 software engineers graduate annually from South African Universities. Therefore, before embarking on the important step of shifting from research to development and commercialization of software solutions, the government needs to start by building math and science capacity and engineering skills. Human resources and IT infrastructure is one of the biggest inputs for developing a software cluster as depicted in **Exhibit 9**. According to the IT industry competitiveness index, South ranks 37 out of 64 countries which are the second country in the Middle East and Africa region(Anon n.d.). Additionally, Johannesburg has the best IT infrastructure in the country. This is an asset for the cluster, but when compared with it's with its global competitors, South Africa still lags regarding IT infrastructure. **Exhibit 10** compares the IT competitiveness of the Gauteng region with some of global competitors.

## Exhibit 9 Software cluster enabler



Source: UNCTAD, Information Economy Report 2012

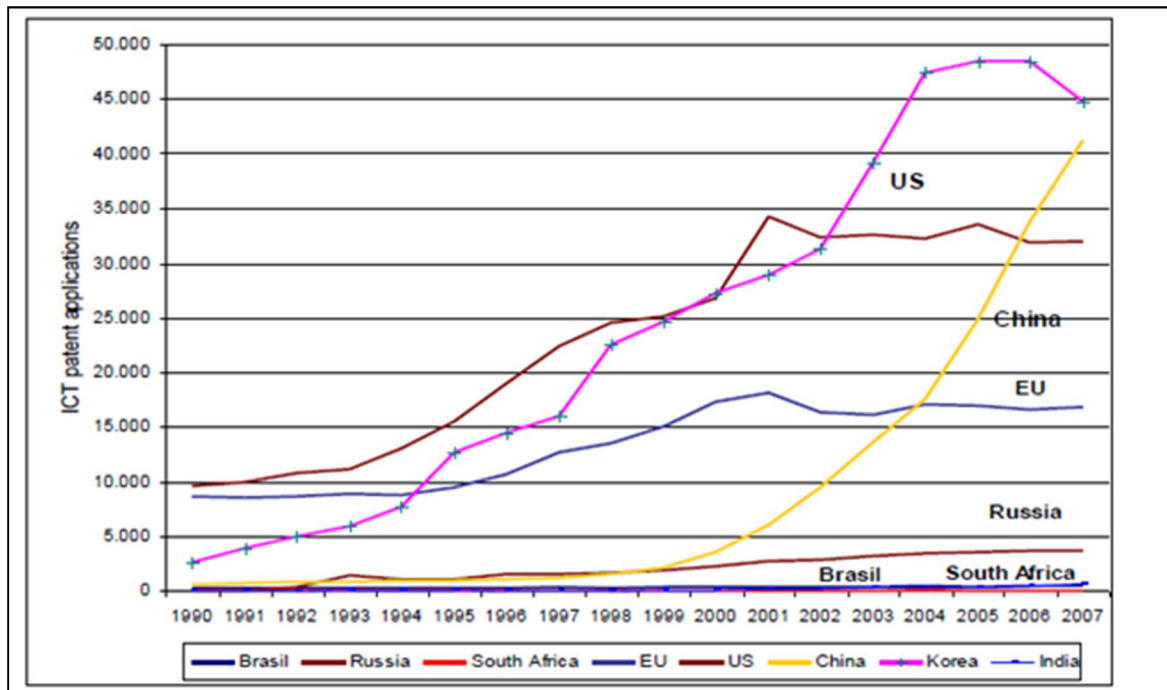
## Exhibit 10: Comparison of the IT competitiveness



Source: Parilla J., Trujillo, J. L., 2015, South Africa's Global Gateway Profiling The Gauteng City-Region's International Competitiveness And Connections

As depicted as **Exhibit 11**, the patent number of patent applications in the ICT sector is very low in South Africa. This shows that there is a need to encourage more entrepreneurship or to improve the patent laws and applications.

**Exhibit 11 Comparison of ICT patent applications**



Source: IPTS, 2011, Priority patent applications to the EPO, the 27 Member States' National Patent Offices, the USPTO, the JPO, and 29 further Patent Offices. Inventor criterion.

The Diamond analysis reveals that the Johannesburg has many of the ingredients of a competitive software cluster, but must continue to invest in R&D, human capital, infrastructure, increase new commercial inventions, expand entrepreneurship, enhance legal and regulatory environment, increase collaboration between stakeholders to develop new products and processes that help its businesses expand into new markets.

#### 5.4. Competing Global Clusters

Competing clusters exist all over the world, from California in the United States to Lagos City in

Nigeria. **Table 1** below indicate global prominent clusters.

Where	Origins	Status
Silicon Valley: USA	Originating at Stanford University (Palo Alto and Menlo Park), and spreading south towards San Jose, California and suburbs <b>SF, in particular</b> , has seen near dominance in particular higher up industries such as web development (2013-2016) and venture capital.	Silicon Valley had maintained dominance for decades in core industries such as microprocessor development and had been the dominant software development centre (including the web) before it lost that crown to nearby <b>San Francisco</b> . Peculiar to the region is an obvious lack of other industries, as technology has crowded them out.
Silicon Wadi: Isreal	Located in an area with a high concentration of high-tech industries in the coastal plain of Israel. The country as a whole has strong innovation capabilities in Cyber Security, Agritech and more. The Silicon Wadi area covers much of the country, although especially high concentrations of hi-tech industry can be found in the area around Tel Aviv, including small clusters around the cities of Ra'anana, Petah Tikva, Herzliya, Netanya, the academic city of Rehovot and its neighbour Rishon Le Zion. Also, hi-tech clusters can be found in Haifa and Caesarea.	Recent hi-tech establishments have been raised in Jerusalem (Technology Park, Malta, Har Hotzvim and JVP Media Quarter in Talpiot), and the Startup Village Ecosystem in the Yokneam area.
Shenzhen Hi-Tech Industrial Park: China	Shenzhen, Guangdong, China Shenzhen municipality and surrounds, including Dongguan's factories had been for a decade the world's dominant peripheral hardware suppliers	Recently Shenzhen has become the dominant place worldwide for hardware startups (excluding microprocessors, chip memory, and pure-play semiconductor foundry).
Technopark-India	Trivandrum is the Asia's largest IT Park situated at Thiruvananthapuram	India as a whole is globally dominant in software technology outsourcing, but not in a single technology park or city.

**Table 1. Competing Clusters**

While these geographic locations can be considered as competing or comparable clusters to the Johannesburg Software Cluster, a more relevant approach should focus on the emerging countries

who share more similarities and challenges are more closely related. The BRICS countries, for instance, are becoming major players not only as ICT users/ importers but also as producers of ICT goods and services. Trade, foreign direct investment (FDI) and the offshoring of manufacturing are very noticeable in Asia, but trade relationships between Asia and Brazil are also worth noting. In other words, the overall impact of these emerging economies is better captured on the global ICT landscape. In this category, Brazil, for instance, is making important progress even though large disparities can be observed. The ICT Landscape in BRICS Countries: Lessons from Emerging Economies report mentions that public policies have supported the improvement of national production and local R&D content. The Brazilian government adopted a "national broadband plan" in May 2010, with ambitious targets on coverage, prices and speed. It aimed to triple the number of accesses, decreasing the price from around R\$ 49-96 to R\$ 15, and increasing the capacity from 256 kbps to over 512 by 2014. It also introduced a special tax regime to deploy broadband. At the same time, there was an attempt to reduce the tax burden on the carriers for telecom services, Tax relief was also used earlier, in 2005, with the Digital Inclusion Programme. The government took the opportunities offered by the FIFA World Cup in 2014 and the Olympics in 2016 for more initiatives. As a result, the software clusters in the country became competitive in the whole region. The same report mentioned earlier proposed a comparison between China and India stressing the fact that former has left the latter behind, and has moved from assembly line workers (i.e. China as the manufacturer of the world) to engineers and scientists (all illustrated by the number of publications in science and technology). He noted China's exceptional performance on high-performance computers (HPC), linked to strong government intervention. No such intervention has been seen in India where the largest computers belong to the private company, Tata. While India leads in ICT service exports, China is racing ahead in ICT goods exports.

It also stressed that one of the key differences with India was the more powerful Chinese government. As regards R&D challenges, it explained major national projects in science and technology, and how the Chinese government is stimulating R&D on next generation mobile wireless broadband technology for the new IMT20 standards within the ITU. In conclusion, it appears that Asia will lead the way, with China and India as the forerunners. These two countries will drive the ICT revolution, and innovation and human capital development.

In Russia, In the ICT sector, the strategy of firms is to rely on existing talents, which have been an output of strong education quality (although there are some issues). Russia is the third largest software development outsourcing destination (behind China and India), and software development here occupies high-end niches (44% market share in Central Eastern Europe). Telecommunications represent almost 70% of the Russian Federation's total ICT sector. Russia is Europe's largest mobile market regarding connections. Russia has gained some global visibility in innovation with success stories such as Kaspersky Lab, a security software company, which ranks 4th among security software companies worldwide. The country will have to make some policy and strategic choices on sustainability, for instance, and also between global integration and regional protectionism.

Beyond the BRICS, Lagos in Nigeria represents a solid competition to the South African model. Most elements for a successful cluster, from funding to talents including institutions for collaboration and universities can be found in Lagos City, however, as it is in the case of the clusters mentioned above, collaboration is suboptimal. Infrastructure is another key challenge, from electricity to access to roads, Nigeria is being challenged on these issues, and some sources claim that at least a 10 billion USD investment will be necessary to lift part of these matters.

Another key difference from the South African model is the absence of Venture Capital Industry in Lagos. While few players claim they provide such services, there are nowhere comparable to what can be found in other similar markets, and access to capital for young entrepreneurs is one of the most challenging issues facing their startups. R&D is another difference. Overall, it appears Nigeria does not have a strategic approach to nurturing companies within clusters, which means it does not have a particular policy in place, yet a vibrant community is somehow being successfully developed there.

## 6. Conclusion and Recommendations

The relative importance of software in South Africa is still quite low (0.52% of total trade in South Africa) despite its huge potential. Given that the software sector has labour replacing and enabling functions, and considering its ubiquity, it generates positive externalities and efficiency gains in the economy as a whole. Unlike the mining or manufacturing sectors, software development does not require huge upfront investment or transportation infrastructure. Instead it spurs from innovation in order to improve the workings of the public and private sector and facilitates social progress. More specifically, software development has the potential to create solutions that address national issues such as tax collection, agricultural extension, public health and power grid management among others. This analysis offers the following recommendations:

### 6.1. Improving the national business environment

There is no panacea for improving competitiveness. One of the efforts the South African government can make is continuous improvement of its national business environment in order to attract FDI into the software cluster and grow entrepreneurship within that space. Addressing key challenges for business operations such as the continued efforts by the government to improve power generation efficiency and capacity are highly commended and further detailed under the



infrastructure sub section 6.3. Improvements in the intellectual property right mechanism of the country are also vital in ensuring that the software cluster remains innovative and competitive within the global landscape.

## 6.2. Human Capital Development

To increase the viability of the Johannesburg software cluster, there is need to increase the quality and capacity of universities to increase and improve the supply of human capital to the sector. This includes a refocussing the curriculum to areas such as Science, Technology, Engineering and Math (STEM) at all levels of the education system (Primary, Secondary and Tertiary). This may increase the level of local graduates in this field and reduce the reliance on foreign workers. The problem of quality education in South Africa is complicated and requires longer timeframe for improvements to be registered. The state of South Africa's education system can be attributed to the country's history which, encouraged racial segregation in schools. Under apartheid, the so called "bantu Education" system was deliberately fragmented along numerous languages. Education was grossly under resourced, low quality teacher training programs and little no performance accountability. Currently, South Africa's average students-teacher ratio is still high. 1 teacher is allocated for 34 students on average, which is the highest among BRICS. Improving students-teacher ratio is one of the key factor in improving education quality in general. In order to achieve this, the Government should consider implementing an outcome-based education system at all levels (primary, secondary and tertiary). Creating an incentive mechanism that rewards the effort of improving teaching quality may translate in better education outcomes and in particular those that relate to STEM as recommended for the development of the software cluster. In order to achieve this, budget allocations to learning institutions should be linked to performance improvement, and tangible Key Performance Indicators (KPI's) need to be agreed with each learning institution that can be monitored and evaluated at various points.

While the existing university network in South Africa churns out a number of graduates every year, the majority end up joining the ranks of the unemployed youth. In order to address this, the government should seek to strengthen the link between industry and the learning institutions. For example, co-sponsoring software development, innovation and entrepreneurship challenges would serve as a connector between talented students and appropriate recruiters and would also attract more students into the field of STEM. Such an undertaking could also help stimulate competition among universities to create the programs that support the growth of the software sector.

### 6.3. Infrastructure

The main point on infrastructure development is about improving efficiency in electricity supply. This could be a relatively quicker solution for improving national competitiveness compared with other challenges because South Africa already has a high urban electrification rate of 94%. It means that the power distribution system is already extended to 94% of the population in the urban areas. Thus, the problem can be attributed to low generation capacity, inefficiency and poor management in the power sector. Considering South Africa's access to private capital, matured Public Private Partnership (PPP) framework, and abundant coal resources, improving these problems can be achieved by expanding generation capacity and introducing management contracts to national power utility ESKOM.

### 6.4. Intellectual Property Rights and R&D

There is need for the government to continue investing in R&D, human capital (as already mentioned), infrastructure (energy sector), increase new commercial inventions, expand entrepreneurship, enhance legal and regulatory environment, increase collaboration between stakeholders to develop new products and processes that help will enable the software sector expand into new markets. In addition to the required financial investment in the sector, there is a

need to encourage more entrepreneurship in the sector through more initiatives like CodeForAfrica, WeThinkCode and AlphaCode. These initiatives offer an alternative pathway for employment for the large number of entrants into South Africa's labour. Proceeding from this is the need to safeguard Intellectual Property Rights in order to maintain incentives for investment in R&D. The efforts of the National Treasury to relax restrictions on property transactions by lifting the approval process is a commendable way forward.

#### 6.5. Institutional Development

Under this analysis, a number of institutions necessary for facilitating the Johannesburg software cluster are mentioned. However, efforts to strengthen their relevance or their iteration to fit the current context and needs for the sector is important. For instance, the South African National Innovation System (SANIS) which is conceptually sound but poorly integrated with the efforts of Johannesburg, the nation's economic engine. Further the role of existing institutions like the JCSE, which is the de facto cluster coordinating organisation, should be elevated and supported in growing the Johannesburg software cluster. Similarly, in order to stimulate the advancement and growth of the digital technology innovation and entrepreneurship in Johannesburg, a stronger role for Tshimologong Precinct needs to be carved out.

#### 6.6. Venture Capital

Johannesburg's Software Cluster is well supported through local Venture Capital Firms in that a significant portion of VC is locally sourced however the total value and number of transactions is relatively low. As mentioned investments in incubator's has increased and the Venture Capital community should be actively engaged to maintain the relationships required to make Capital responsive at all levels of need and in each round of investment.

### 6.7. Implementation of Economic Strategies

This analysis references three economic development strategies that intervene at the national, provincial and city level that support the development of the software cluster. These include South Africa's National Development Plan, Transformation, Modernization and Reindustrialization of the Gauteng City-Region and the Growth and Development 2040 Strategy for Johannesburg. While these medium to long term frameworks are well intended, there is need to ensure that they are implemented in order to realise the growth of the software cluster as a leverage point for economic growth and development.

A deliberate strategy to develop Johannesburg's Software Cluster will require coordinating a disparate group of individuals and firms. The recent spike in entrepreneurial and MNC activity must be matched with coordinated efforts from government to take advantage of the opportunities to better collaborate and coordinate across the cluster.

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