BANKSETA Research Chair in Digitalisation: Desktop Research Reports

CONTRACT NUMBER	***475.4710.644***
START DATE	***05 October 2018***
END DATE	***28 February 2020***
TRANCHE TWO	***30 June 2019***
REASEARCH PROJECTS	***Desktop Research Projects:*** • ***Fintech Development in South Africa*** • ***Post School Education and Training and 4IR***
CONTACT DETAILS (RESEARCH CHAIR IN DIGITILISATION): **Name,** ***Telephone & Email***	***Dr Surendra Thakur*** ***031 3736991*** ***thakur@dut.ac.za***

Approval and Sign-off

30 June 2019

_____ **_____**

DUT **(Date)**

_____ **_____**

Head of Research: BANKSETA **(Date)**

Contents

BANKSETA Research Plan: Topic 1

TITLE OF RESEARCH	Analyse the state of current fintech development in South Africa and prepare a business case for the establishment or support for a fintech incubator working closely with the South African Reserve Bank on their approach to Fintech Development.
CONTRACT NUMBER	***475.4710.644***
START DATE	***05 October 2018***
END DATE	***28 February 2020***
TRANCHE TWO	• ***Desktop Research Report*** • ***Database of Fintech Companies***
Due	***30 June 2019***
Version	***001***
Prepared by:	***Durban University of Technology***
Prepared for:	***BankSeta***

Approval and Sign-off

30 June 2019

_____ _____

DUT **(Date)**

_____ _____

Head of Research: BANKSETA **(Date)**

Executive Summary

Fintech companies that were initially classed as disruptors in the financial services space have grown in the last decade. Their ability to disrupt traditional banks and better service client needs have provided an opportunity for investors to help these organisations grow. On a global scale, some of these Fintech save become well established businesses. Desktop research indicates that there are over 100 Fintech companies in South Africa. To ensure that these businesses become sustainable and are capable of competing globally, they must be given the right type of support.

Research Process

This research comprised solely of a desktop study. This a process of gathering data using secondary research, that is, research data that already exists to gain a better understanding of the fintech space globally and in South Africa. The data was sourced from the website of fintech companies as well as organisations that support fintech companies like hubs, events companies, venture capital companies and so on. The internet was the sole source from which articles, reports and other data was extracted. The on-line search was used using the google search engine and the results found provided in-depth data needed for this study.

The team conducted a thorough in-depth desktop analysis of fintech companies that are in operation internationally, in Africa and in South Africa. They found information relating to basic details of the companies, what services they offer and contact details, amongst other information. The method was a quantitative analysis of the top 100 global fintech companies and the list of South African Fintech companies. Research today is not a static process and therefore the findings presented in this report provide a broad analysis. There may be more fintech companies that is not covered in this report.

Chapter 1: Understanding FinTechs

Broadly speaking, FinTech (financial technology companies) is any company that applies technology in providing financial services or used to help companies manage the financial aspects of their business, including new software and applications, processes and business models. Once considered more of a back-end, data center processing platform, FinTech has in recent years come to be known as the basis for end-to-end processing of transactions over the Internet via cloud services. The South African Reserve Bank describes FinTech as technologies applied to financial services with the potential to disrupt current business models, applications, processes or products.

According to Deloitte and the WEB, disruptive forces that have reshaped the FinTech industry include, but are certainly not limited to:

- The growth of online shopping, which is expanding quickly at the expense of in-person shopping, leading to the dominance of online, cashless solutions for transactions.
- A shifting balance of power that swings from banks and other financial services to those who own the customer experience. Banks are eliminating in-person services and looking to FinTech and large technology companies for other ways to engage customers.
- New trading platforms that are collecting data to create an aggregated market view and using analytics to uncover trends.
- Insurance products, which are becoming more tailored to customers who, in turn, are demanding coverage for specific locations, uses and timeframes. That's driving insurers to collect and analyze additional data about their clients.
- Artificial intelligence, which now plays a role in differentiating financial services products as it replaces complex human activities.
- Transaction process improvement and middleware, both of which remain expensive. This is pushing traditional financial services firms to consider partnerships with marketplace lenders for FinTech solutions that don't require a full infrastructure overhaul.

Chapter 2: Fintechs on a global scale

The top 100 ranked Fintech listing is a collaboration between fintech investment firm H2 Ventures and KPMG. The Fintech100 were selected following extensive global research and analysis based on data relating to five factors. Two criteria are related to capital raising reflecting the emphasis that venture capitalist investors place on the ability of firms to innovate in order to generate a long term sustainable competitive advantage.

FinTechs were assessed using the following criteria:

- Total capital raised
- Rate of capital raising
- Geographic diversity
- Sector diversity
- X-factor: degree of product, service and business model innovation.

The table below shows the top 100 Fintechs for 2018:

Name of Fintech Company	Description	Category	Country
Ant Financial	Technologies, including Blockchain, AI, IOT, etc	Multi	China
JD Finance	Digital technology	Multi	China
Grab	Offline to on-line mobile platforms	Multi	Singapore
Du Xiaoman Financial	Short term loans and investment services	Multi	China
SoFi	Online finance company, student loans, etc	Lending	United States
Oscar Health	Healthcare big data and machine learning	Insurance	United States
Nubank	Mastercard credit card with no fees	Neo-bank	Brazil
Robinhood	Zero fee stock trading app	Wealth	United States
Atom Bank	Digital bank	Neo-bank	United Kingdom
Lufax Holding	Internet based wealth management platform	Wealth	China
OneConnect Financial Technology	Technology provision	Multi	China
51 Credit Card	App for credit card bills	Wealth	China
Revolut	Digital banking alternative	Payments	United Kingdom
Compass	Real estate technology company	Payments	United States
Stripe	Payments online and on mobile apps	Payments	United States
Clover Health	Data driven health insurance	Insurance	United States
Adyen	Payments platform	Payments	Netherlands
Policybazaar	Digital insurance	Insurance	India
Klarna	e-Commerce payment options	Payments	Sweden
ACORN Oaknorth Holdings	Platform for lending	Lending	United Kingdom
Kreditech Holding	Access to credit for the underbanked	Lending	Germany
Monzo	Digital bank	Neo-bank	United Kingdom
WeLab	Innovate traditional credit services	Lending	China
Number 26	Mobile banking app	Neo-bank	Germany
WealthSimple	Online investment manager	Wealth	Canada
AfterPay Touch	Instalment plan for online shoppers	Payments	Australia
Dianrong	Customise lending products	Lending	China
VivaRepublica	P2P mobile payments platform	Payments	Korea

QUOINE	Trading powered by blockchain technology	Wealth	Japan
Kabbbage	Online lending	Lending	United States
Affirm	Point of sale lender	Lending	United States
OurCrowd	Equity crowdfunding platform	Wealth	Israel
SolarisBank	API accessible banking	Neo-bank	Germany
Future Finance	Student lender providing loans to students	Lending	Ireland
Neyber	Provide financial management products to employees	Wealth	United Kingdom
ZhongAn	Online property insurance company	Insurance	China
TransferWise	Money transfer service	Payments	United Kingdom
Pushpay	Donor management system	Payments	United States
League Inc.	Health insurance	Insurance	Canada
Circle	Bitcoin and digital currency	Payments	United States
Lendingkart	Access to working capital	Lending	India
Opendoor	Buying and selling homes	Payments	United States
Metromile	Car insurance through pay per mile	Insurance	United States
Folio	Online security brokerage	wealth	Japan
Lendix	Funding options	Lending	France
GuiaBolso	Better understand financial health	Lending	Brazil
Starling Bank	Mobile only bank	Neo-bank	United Kingdom
Coinbase	Digital currency transactions	Payments	United States
Airwallex	Cross border transactions	Payments	Australia
Lemonade	Licensed insurance carrier	Insurance	United States
Agri Digital	Commodity management solution for grain	Payments	Australia
Anyfin	Refinance existing loans	Lending	Sweden
Aqeed Technology	Digital insurance	Insurance	United Arab Emirates
Bankera	Blockchain banking	Neo-bank	Lithuania
Blackmoon Financial Group	Blockchain based investment company	Financial services	Malta
BlockFi Lending	Loans backed by cryptocurrency	Lending	United States
Brex	B2B financial products	Payments	United States
Cashaa	Blockchain platforms	Neo-bank	United Kingdom
Cellulant	One stop payment in Africa	Payments	Kenya
Cleo	Artificial intelligence	Wealth	United Kingdom

Coya	Artificial Intelligence personalised risk cover	Insurance	Germany
Crypterium	Mobile payments in cryptocurrency	Payments	Estonia
DAYLI Financial Group	Technology provision	Wealth	Korea
Dreams	Digital banking alternative	Wealth	Sweden
Funding Societies	Online platform that connects investors with business	Lending	Singapore
Geru	Unsecured loans	Lending	Brazil
InstaReM	Digital cross border money transfers	Payments	Singapore
Konfio	Online lending platform	Lending	Mexico
Kredivo	Digital credit card	Payments	Indonesia
Kyber Network	Exchange and conversion of digital assets	Payments	Singapore
Liwwa	Peer-to-peer lending platform	wealth	Jordan
Look Who's Charging	Transaction identification	Other	Australia
MoMo	Mobile, electronic wallet	Payments	Vietnam
Nod	Natural language AI platform	Other	Australia
Omise	Online payment enabler	Payments	Thailand
Payr	Innovative banking services	Payments	Norway
Paysense	Consumer lending platform	Lending	India
PayTabs	Global payments provider	Payments	Bahrain
Pleo	Spending solution for employees	Payments	Denmark
Plussimple	Insurance robo-broker	Insurance	France
Polymath	Decentralised protocol to raise capital	Payments	Barbados
Power Ledger	2P solar energy trading	Payments	Australia
Pundi X	Transact in cryptocurrency	Payments	Indonesia
Quantexa	Make better decisions from their data	Other	United Kingdom
Recordsure	innovative analytics and automation platform	Other	United Kingdom
Ripio Credit Network	Financial payments	Payments	Argentina
Shift Technology	insurance and e-commerce	Other	France
Singlife	Independent Life Insurance Company	Insurance	Singapore
Tala	Credit scoring and reporting platform	Other	United States
Tally Technologies	Automate customers financial life	Other	United States
TenX	Send and spend crypto-money	Payments	Singapore
ThisIsMe	Identification technology	Other	South Africa
Tide	Mobile-first banking service	Wealth	United Kingdom
Tiger Brokers	Online brokerage	Wealth	China
Tpaga	Mobile wallet for the unbanked	Payments	Colombia
Trade Ledger	Business lending platform	Lending	Australia

VaroMoney	Technology and mobile business	Neo-bank	United States
Wallet.ng	Digital wallet	Wealth	Nigeria
Wave Money	Mobile financial services provider for the unbanked	Payments	Myanmar
WeBank	Private commercial bank that uses facial recognition	Neo-bank	China

Chinese fintechs continue to dominate the top of the list, accounting for three of the top five places on the Leading 50 list with Ant Financial in first, JD Finance second and Baidu fourth; Singapore's Grab was a new entry, taking third place, and US fintech Sofi moved up to fifth place. The US tops the Fintech100 with 18 fintechs placed, including three of the top 10, followed by the UK with 12 and China with 11. Australia and Singapore place strongly with 7 and 6 fintechs respectively. Payments companies dominate the Fintech100, with 34 in total, followed by 22 in lending, 14 in wealth management and 12 in insurance.

One South African company features on the 100 list – ThisIsMe, which aims to bring trust into transactions through proprietary, true identification technology. Started in 2013, the platform enables businesses to reduce fraud, automate KYC checks, improve on-boarding and increase revenue while providing an on-demand, seamless customer experience. "ThisIsMe holds the record for the fastest FICA verification at three minutes. The company uses an array of tech that includes artificial intelligence, bio-metrics, machine learning and tamper detection."

Chapter 3: Fintechs in South Africa

Fintech has become a big deal in South Africa in the last couple of years. A large part of the African population is unbanked (They do no use the services of traditional banking systems). Because of this, an implementation of new ways to approach these problems became relevant, that's when the Fintech companies stepped in. Especially in South Africa the demand for innovative products and new, digital solutions for financial issues have been pushing South African Fintech companies forward. In 2015 alternative finance platforms raised $15 million, a major part of it was coming directly from peer-to-peer consumer and business lending, the remaining was raised through donations. Only 3 years after, in 2018 the raised money for South African start-ups had risen from $15 to $168.6 million. With this number, Fintech in South Africa and generally on the whole African continent remains to be on the top position with the most funding. Therefore, it is not surprising that there are start-ups in South Africa that the whole world needs to look for in 2019.

Fintech definitely is a new wind for South Africa that will have a huge impact on the country's economic development. The SA government is well aware of it, that is why the South African Reserve bank (SARB) established a fintech-unit in January 2019. The unit consists of three people with the main task to monitor the fintech sector and its effect on traditional banking methods. Since 2009 South Africa has been adopting a pro-innovative stance. At that time, the South African Reserve Bank had issued a paper on digital money and stated that it welcomed the innovative solutions in the financial sector. The government even launched a Fintech Program to analyze fintech development and help policymakers to formulate a legal framework for the new, digital era in finances.

Most of the fintech start-ups in South Africa are concentrated on the five major banking functions: payments, capital raising, deposits, lending, investment management, and market provisioning. As for the other side of fintech which is focused on investment, asset and wealth management, the activity from the start-ups in South Africa is minimal, but with the rapid growth of innovative services it is possible that soon SA fintech companies will start providing these digital services as well, once the traditional banking services are covered.

There are over 100 registered Fin Techs in South Africa. Their services range across many different areas.

Alpha Exchange

Alpha Exchange is the first open knowledge exchange for the capital markets community. Alpha Exchange is a next generation institutional research and knowledge sharing platform. The team brings disruptive technology to an archaic, legacy driven capital markets industry that has seen very little innovation since the first Bloomberg terminal. Alpha Exchange is the first open financial network and knowledge exchange for the capital markets community. Transforming the way analysts interact, share knowledge and discover investment insight. Alpha Exchange helps investors cut through market noise to deliver intelligence that drives better-informed investment decisions.

AMF Tech Africa (PTY) LTD

New co, payment and switching asset management fund, for Africa. Developing the Next Gen Switch, with BlockChain, Virtual Mall Payment Technology.

Bankymoon

Bankymoon is a software and consulting firm with expertise in Blockchain technologies. They develop bespoke solutions for clients who require Bitcoin and other crypto-currency integrations. At its most fundamental it is a **distributed transaction ledger** which is encrypted, stored and verified for consistency in a peer-to-peer network. It enables, for the first time in history, digital assets to be transferred safely and securely and the ownership of those assets to be verifiable by independent parties.

Bitsure

Bitsure provides an innovative payment solution by utilizing the blockchain technology to link customer profiles to fiat-backed cryptocurrency transactions in order for financial institutions to create a secure and instantaneous, low cost payment process to its customers. Bitsure will disrupt traditional card payment methods by using a blockchain and a fiat-backed cryptocurrency payment network that completely bypasses the Payment Card Industry (PCI) (e.g. Visa, MasterCard, American Express, etc.).

Bizcash (PTY) LTD

Bizcash was created by entrepreneurs, for entrepreneurs, in order to be part of the solution. Partnered with Reichmans Capital, the Bizcash system is designed to empower businesses by providing a new way of thinking about cash flow. They help your business close cash flow gaps by turning outstanding debtor's invoices into instant cash. Bizcash links directly into the accounting package to make getting cash against invoices even simpler.

Creditable

Creditable is a platform that integrates inbound company credit solutions, credit worthiness in minutes & provides savings/insurance products to employees. Creditable is a cloud based financial tool that enables caring employers to offer financial wellness products to their employees. A third of an employee's life is spent with an

employer. Creditable is the first truly SaaS pay-as-you-use tool and it is the only product that uses bank data aggregation to assess credit risk and affordability. Employers and employees alike gain from Creditable's fair, professional & transparent loaning.

Crowdcoin

CROWDCOIN, lets prepaid and top-up subscribers exchange airtime for cash, send/receive money and make purchases using airtime by entering commands on a mobile phone in South Africa. This sort uses pre-paid mobile airtime minutes as a de facto currency that can be transferred between phones and exchanged for cash with Crowdcoin's help to trade airtime for cash. Crowdcoin works much the same like a traditional bank account, once you deposit funds into your account you can then use the available balance to make payments and purchases.

Cubebucks

Cubebuck offer the solution to digitize money, backed by the security and safety of the cryptocurrency blockchain. Cubebucks as a seed startup aim to offer the stability of exchange between the US $ and digital currency by applying an application layer to the block chain protocol. The block chain and all digital payments are in need of a middle ware to facilitate easy access and transferability between them. By having a middleware value system linked to physical resource any value system and trade mechanism can be accommodated on the innovative model presented by the Cubebucks virtual currency system. When you convert your asset to **qb**, you are assured that the value loaded or received today has the same value when you wish to trade. Cubebucks developed their Crypto currency ledger using PBFT algorithm developed at MIT. The algorithm is the core foundation of the system combined with the Bitcoin proof of work authentication method.

Cubebucks LTD

CubeBucks is a secure, safe asset-backed cryptocurrency build on a multi-dimensional blockchain as a partially distributed ledger that is used for real-time payments. The underlying value of CubeBucks is established on a risk profile-based user-defined allocation of a portfolio of asset classes. The CubeBucks wallet offers innovative features like Cross-Chain exchange for all forms of cryptocurrencies, the micro-payments platform for internet transactions and person to person digital cash payments.

Curve

Curve is a replacement for your conventional Bank Account for small business, entrepreneurs, students, individuals, families, and friends. Curve is free, and you get a card like you do from your old Bank. You can deposit and spend your money anywhere in the world that accepts the main card issuers. You can use ATMs to access your money, and you use the revolutionary Curve App to power a new world of services you never thought possible. Our ethos is everything has to be able to be done in 30 seconds or less, and that you never again apply for a financial service and get declined. With Curve, you only see what you qualify for, and we'll work with you every step of the way to improve your financial health every day.

Custos

Anti-piracy for media by embedding a digital watermark in the file, specifically bitcoin, stopping piracy at the source. CustosTech provides a way of detecting the sources of leaked media. It achieves this by imperceptibly marking each copy of a digital media file that is entrusted to a recipient. This “watermark” directly identifies the recipient. What makes CustosTech unique, is that it rewards individuals in piracy networks across the world to report on pirated content Individuals (“bounty hunter”) who know where to find pirated content are rewarded when they find new infringements. This is done by embedding a reward in the form of digital currency (Bitcoin) directly in the copies of the media that are sent to recipients. When an anonymous bounty hunter claims the bounty, Custos can immediately detect the leak and inform the client of who the original recipient of the media was.

E4 Strategic (PTY) LTD

Virtual identity digitally enables the fica process for accountable institutions. Virtual Identity is a digital solution and takes the pain out of the FICA process for clients and institutions alike. Virtual Identity is accessible over the Web or through an App (Android & iOS). This allows a client to interact with an institution over a video conferencing link, facilitating a face-to-face discussion. The client can supply evidence of their identity and proof of address by taking photos of their original documents and submitting them to the Agent for review and approval. This is an easy to use solution that allows a client to complete the tedious FICA process from the comfort of their home and in under 5 minutes. Institutions obtain all required documentation and have full audit records of the process and they can fulfil all their obligations without the physical meeting.

Easyequities/ Satrixnow

Easyequities is an online investment platform which makes it fun, easy and cheap for anyone to buy shares. The platform has replaced the jargon and intimidating fees you'd expect to find on other stockbroking platforms, with simple explanations and helpful recommendations.

Entersekt

Entersekt is an innovator in push-based authentication and app security. The company's one-of-a-kind approach harnesses the power of digital certificate technology with the convenience of mobile phones to provide financial services companies and their customers with full protection from online fraud. Built on open technologies for high availability, scalability, and simple integration, Entersekt's patented security products protect millions of devices and transactions daily, while complying with the world's most stringent regulatory guidelines. Enterprises across the globe look to Entersekt to strengthen the bond of trust they share with their customers, and to build on those relationships by introducing compelling, user-friendly new mobile and online services.

Finchatbot

They design bots helping clients connect with their digital audience through new communication channels. Combining wisely designed scenarios and AI to make the user experience more personalised and enjoyable. Indeed, we run complex machine learning algorithms able to cluster relevant data together. As a consequence, our bots will automatically learn how to speak with each specific customer. The more experience our bots have the more they learn and the more genuine the conversations will be. Secondly, by automating customer support, we reduce our clients call-centre costs so they can offer more competitive prices for their customers. Simultaneously, our bot will be able to lighten the amount of work for call centres agents and tackle all the tedious tasks.

Fincheck

Financial inclusion is only a small step in enabling new market entrants opportunity to an included life. Fincheck.co.za is a user-friendly online portal which provides totally independent, unbiased and transparent

facts and figures about similar financial services products on offer from different financial services institutions. Fincheck.co.za allows users to compare 32 different financial products from various financial services providers. These range from loans (personal and student), cheque accounts and debit cards all the way through to foreign exchange and unit trusts. The number and range of products available for comparison on Fincheck.co.za are growing all the time. Fincheck helps users choose the product which will best suit their needs and their pockets. Targeting ordinary South African consumers who do not need high levels of financial literacy to use the portal, Fincheck empowers them to make critical financial decisions based on accurate information before making a commitment, and before entering into the financial services market.

Fintec Labs (PTY) LTD

They are receivable optimisation specialists, using big data, machine learning and cloud computing to help corporate clients collect their monthly debtors invoices more efficiently while helping banks get back in the game. The best cost routing platform provides a straight-through process for each invoice to be routed to the best electronic collection channel automatically using analytical action triggers. Dunning messages are A/B tested for optimal efficiency lift. Deep insight reporting gives the Treasurer accurate cash flow forecasts on cohorts and KPI triggers provides time sensitive priming on next best actions.

Geopay

Geopay is a peer to peer blockchain remittance platform for people living in the diaspora to transfer money across-border instantly cheaper, faster without any bitcoin knowledge necessary. This is done through a network agent in the informal settlement to cater for the unbanked population mainly in Africa. GeoPay charges very minimum cost of less than 3% per transaction allowing users to do micro transactions for the financially excluded population between countries for grocery items, education, health and sanitation

Getbiz

GetBiz is a world-class, real-time tender notification service that connects tender issuers with suppliers. We also provide insightful, multi-media news content that helps our subscribers grow their businesses by helping them achieve substantial savings and find new business, no matter which sector of the economy they operate in.

Global Group Franchising PTY LTD

Global Group Franchising Pty Ltd (GGF) provides an alternative way of funding franchises using the crowd funding method. The existing way of funding franchises requires the approved franchisee to have at least 40% or 50% of the total amount depending on a bank. The shortfall can be financed by a bank through a loan. The existing way also requires the franchisee to qualify for the credit required. GGF offers a finance facility to the franchisee from a pool of funds from the crowd (i.e. ordinary people, stockvels, communities, etc) instead of a loan from a bank. This facility makes it possible to finance franchisees who are trusted by franchisors with less than 40% of the franchise amount and/or do not qualify for credit from the bank. The crowd (i.e. ordinary people, stockvels, communities, etc) will own shares in the franchise outlet and share profits according to how much they have contributed towards funding the franchise outlet. When they sell their shares, they will also get capital gains if the value has gone up.

Ground Flr

Ground Flr is changing the way emerging markets startups look for funding and in so doing improve their chance of success. Opportunity is the only difference between those in developed markets and those in emerging markets. Ground Flr is an online platform connecting emerging market entrepreneurs & global investors.

Hello Paisa

Hello Paisa, a low-cost International Money Transfer service that is accessible from your mobile phone in just a few simple taps, so there was Money transfer and now there is Hello Paisa.

ICE3X

iceCUBED X have been providing customers with a safe and secure way to acquire bitcoins since 2013. iceCUBED X is your ideal trading partner to BUY or SELL bitcoin in South Africa. Account registration is quick and easy and our awesome support team are ready to assist you with any queries you may have.

Ikhokha

iKhokha is a proudly South African MPOS solution that enables all South African SME's to accept debit and credit card payments anywhere, any time and on any device. And that's not all - the iKhokha App allows business owners to track their sales performance through built in business analytics in real time.

IMB

Access to IMB's services is the first step toward financial inclusion for these neighbourhoods since it allows people to store money safely, send and receive payments and provides a gateway to other financial services. At IMB, we believe that one of the biggest opportunities of this era lies in bringing innovation to unserved financial markets by leveraging technology to provide transactional services to these neighbourhoods and, using the same technology, to allow previously untapped human capital to build a sustainable business through the provision of IMB services. IMB closes the loop and empowers entrepreneurs from these neighbourhoods, with no prior skills or experience, to ensure that their communities' benefit from financial inclusion.

InvoiceExchange

A web-based platform that supports and enables companies to sell their invoices and purchase orders on an exchange and attain immediate payment. The Invoice Exchange (IX) is a web based company that supports and enables small and medium-sized businesses (SMB's) that supply blue chip companies and government to sell their invoices and finance their purchase orders on an exchange to attain immediate payment. We are the market place for invoices and purchase orders. We provide a way by which financial institutions (Investors) can earn prime plus interest rates for highly rated blue chip company paper (Invoices) and purchase orders.

Invoset PTY LTD

InvoSet is a revolutionary online Invoice Payment System allowing Buyers to get additional extended terms at no cost and simultaneously allowing their Suppliers to be paid Cash on Delivery. InvoSet has developed a process that is transparent, easy to use and benefits both Buyers and Suppliers, allowing them both to achieve improved cash flow through our technological solution.

I-Pay

Our software allows a consumer to effortlessly access and make secure, instant EFT payments directly into a merchant's bank account. I-Pay facilitates transactions via e-commerce, mobile, eBilling and in-store transactions, saving the consumer time, and also saving the merchants money. The system is completely card-less and transactions are concluded in under 45 seconds. Payments can be made via eCommerce sites, SMS, Email, QR Code or via Push Payments. Unlike the traditional payment methods, there is no need for consumers to load beneficiaries, reference numbers and amounts due for payment. The software automatically populates this information, mitigating the risk of the consumer capturing information incorrectly. The merchant has absolute certainty that the amounts will be received on all successful transactions and are allocated accurately, based on the reference number linked to the payment.

Ipreo (PTY) LTD.

Since its inception, Ipreo has transformed global capital markets by finding new ways to connect them. Ipreo's data and solutions are critical to connecting market participants and enabling the efficient execution of capital-raising activities.

Iveri Payment Technologies

iVeri is an experienced payment technology company serving financial institutions and banks in in over 10 countries. iVeri's Payment Gateway is a PCI certified omni-channel payment solution that supports multiple-channel card acceptance across PoS, eCommerce, Mobile, and Batched payments. By providing a local or certified SaaS solution, iVeri enables both established and new acquiring banks with a rapid, tried and tested solution, thus enabling them to own the last mile of payment acceptance.

JUMO

Jumo is providing traditional banking services with an innovative digital way through its JUMO app to the unbanked population of Africa. Last year, JUMO became the first start-up from South Africa that was chosen by Google for its launchpad accelerator. South African Fintech start-up JUMO seems to have big plans for the future and is definitely worth the attention. JUMO is a Mobile Financial Services platform at the core of mobile money

ecosystems. Our technology powers real-time access to credit, savings and more. They use data to understand what financial opportunities people need and then we put the power of that choice in the palm of their hands.

Jumpstart

Jumpstart is a preeminent South African equity investment platform, combining the best of venture capital with equity crowdfunding. We provide investors the opportunity to invest in start-ups alongside Venture Capital firms and angel investors (both primary and secondary investment opportunities). Jumpstart does not require the typical large investments that have traditionally closed off the world of early stage start-up investing, instead, investors can invest with as little as R10 000. For investors looking for high-growth investments, this type of access to start-up investing in private companies is virtually unheard in traditional Venture Capital investing.

Kineto Mobile

KINETO MOBILE's, feature rich, multi-faceted & private cloud-based wallet platform leverages multiple technology channels, to empower our clients consumer's to securely access financial, vending & other beneficial products, and services, so as to transact online within a financially inclusive ecosystem of Role-players, Communities, Financial Institutions, Mobile Network Operators, Value Added Products & Service Providers & Retailers.

Livestock Wealth

A crowd-farming company that enables anyone to invest in cattle. Livestock Wealth expertly manages and operates two farms: Fairplay in Zululand, Vryheid and Rietfontein in Kokstad, KwaZulu Natal, South Africa. The current farms have carrying capacity of a 1000 head of cattle. We aim to grow the cows under our management to 1 million by 2020 in different farms in South Africa and beyond.

Lulalend

Lulalend is an online & automated provider of short-term business funding. Through cutting-edge technological development and automation of the application process, we are able to say 'YES!' more often and faster than traditional lenders.

Luminous

For more than ten years Luminous has been working with banks to create innovative ways to engage customers with value-added services beyond their core banking products. One of our customers was voted most innovative bank in the world and we believe our solutions played a significant role in this. Luminous has a full suite of accounting and credit products with a particular emphasis on the acquisition and analysis of data from small and medium business, as well as from individuals.

Luno

Luno is a leading global digital currency company with a team of over 70 technology and finance experts, operating in 40 countries. Our products and services make it safe and easy for people and businesses to store, buy, use and learn about digital currencies like Bitcoin. Their vision is to empower billions of people by bringing digital currencies to everyone, everywhere.

Maxicash

A virtual wallet allowing African expats globally to support their families and friends back home. We've developed an app for African expats to send money to their families in Africa without using any traditional "agencies" or "bank". Maxicash allows you to purchase and make payments from our wide variety of mobile partners. Buying Airtime from African Telecommunication providers has never been easier. Sending E-vouchers gifts is now one step closer.

Merchant Capital

An innovative solution for small and medium businesses struggling to access working capital for growth. Merchant Capital provides micro-enterprises and SMEs in South Africa that are unable to access traditional loan

facilities with unsecured cash advances. Qualifying SMEs receive a lump sum payment within 24-48 hours in exchange for a fixed percentage (5-15%) of future debit/credit card turnover.

MFS Africa

MFS Africa is a pan-African Fintech company that develops innovative value-added services for mobile wallets. The company works in close partnership with mobile network operators and financial institutions to bring simple and relevant financial services to un- and under-banked customers. MFS Africa currently connects over 100 million mobile wallet customers in sub-Saharan Africa through its partnerships with leading mobile wallet providers, such as MTN, Orange, Vodafone, and Airtel. The MFS Africa Hub also connects money transfer organizations and banks to mobile wallets in Africa, allowing each to take advantage of the growing popularity of mobile wallets as safe, convenient, compliant, and cost-effective delivery channel for international remittances.

Mobicred

Mobicred provides a virtual revolving credit account, in real time, for hundreds of merchants, allowing them to increase average basket size and monthly revenues. Consumers are able to shop across hundreds of merchants with a centralized account.

Mobilife

MobiLife seeks to transform micro-insurance outcomes to lower income consumers in South Africa. We combine innovation across product, process and technology, with the biggest consumer trend of the next decade (empowerment of the poor via access to the internet on their smartphones). MobiLife is an entrepreneurial venture started by three life insurance professionals.

Moneysmart By Limitless Technology Group

A new way to live work and play with your money: See how much you can spend daily. Moneysmart helps you to stretch your money till the end of the month! We call it, Daily Available Cash - Link all your cheque, savings, credit card accounts into one app with a single view. Get automatic updates when you log in every day. Always

know what you can spend and where you can save. - Review your spending patterns and identify where you overspent. - All your transactions are categorised into spending categories. See the places you've spent at, how much and when. - Plan your cash flow forecast, adjust your spending ahead of time to make it through the month. Plan how much you need today, tomorrow, this weekend. -Even when you spend more than planned, moneysmart picks that up automatically and intelligently updates your Daily Available Cash

Mukuru

Mukuru is breaking down the barriers for money transfers in Africa. They enable instant cash-to-cash transfers, bank account top ups and mobile wallet loads across 8 African countries and our reach is continually expanding. All you need to get started is a mobile phone or internet enabled device.

M-vendr

M-vendr Technologies is a pre-paid product distribution and cash payment collection App as a Service (AaaS) provider. Through our mobile POS App, prepaid value distribution and payment aggregation solutions, we are revolutionising the way pre-paid voucher products, payments and financial services, are delivered to underserved customers across the globe. The mobile Point of Sale (mPOS) App enables small retailers and informal traders to increase revenue and footfall reselling pre-paid digital products like Mobile Top-up, Gift Cards, International Remittances and accepting Utility bill payments from their customers without the need for the traditional POS hardware terminals. M-vendr enables our clients to provide prepaid mobile recharge/top-up of any value, anywhere, at any time, through their retail distribution channels utilising our white label mobile POS or on-line using our API.

My Treasury

They are able to compare insurance quotes, grocery prices and even business funding options; now there is a start-up that wants to help individuals compare saving options. The savings market is extremely complex and opaque. It has been virtually impossible until now to find the optimum place to invest your savings. The MyTreasury's Savings Optimiser makes it easy for anyone to instantly find the right bank account. This service

is free and provides options based on a few simple questions. My Treasury takes into account factors such as the amount you want to deposit, whether it's a fixed or "top-up" amount, your age and your current bank.

Nomanini

Nomanini, meaning 'Anytime' in siSwati, is a South African-based enterprise payments platform provider that optimises transactions in the informal market. Nomanini enables financial inclusion via local informal retail merchants, who already serve as a daily touch point for over 80% of people in Africa. Nomanini enables merchants and agents to facilitate a wide-range of basic transactions including mobile top-ups, utility payments, remittances, deposits, withdrawals, account opening and mobile money/card acceptance. Nomanini works with banks to enable existing third-party merchant aggregators, such as mobile and FMCG distributors, to acquire and serve merchants efficiently.

Outvest

OUTvest, has changed the personal investment journey by embedding investment advice, administration and the actual investing into a single user journey. As a hybrid Robo-advisor, they offer a combination of digital and human advice using one administration platform. This combination allows clients to focus on achieving their investment goals rather than selecting the right investment strategy. Access to the OUTvest offering is done online (web version) or through the OUTvest app. The interface incorporates a 'chatbot' style interaction and can build a professional standard investment plan which best suits a client's investment goals, you can start investing from as little as R100 per month.

Paycode

Paycode is an end-to-end payment technology company. Their vision is to give biometric identity and affordable access to basic financial services to the unbanked. The technology still works in low connectivity areas. In the event of zero connectivity, two transactions (Make A Payment or Withdraw Cash) can be done offline in real-time.

Paycorp

Paycorp is a leading provider of payment solutions in developing economies. They deliver safe, easy access to cash and payment services to millions of under-banked people in developing economies through 5500+ ATMs, 22000 POS and vending terminals & 500+ card programmes in 16 countries across sub-Saharan Africa and South East Asia, with a fledgling business in Eastern Europe. Paycorp has continued to create a series of firsts including the first wireless communication ATM and the first solar powered ATM.

Payfast

PayFast is a payments processing service for South Africans and South African websites. They enable easy, secure and instant transfer of money from online buyers to sellers. They allow sellers –individuals, businesses and charities– to accept secure payments from online buyers in a variety of ways.

PayLiquid

PayLiquid is a professional service provider using intelligence, technology and human expertise to successfully provide financial solution to individuals, corporates and parastatals and community as a whole. They enable and provide financial solutions, tax and accounting platforms using their unique payroll, prepaid cards, mobile banking, debit order and payroll software to our subscribers with very secure platform guaranteeing safety and security for all transactions.

Payspace

PaySpace is a scalable, agile, multi-country, 100% cloud-based application that unifies Payroll, HR, Talent, Recruitment, Performance and Time Tracking into a single record. With embedded analytics, manager and employee self-service, and a user experience designed for mobile, PaySpace enables businesses of all sizes to run a compliant best in class people management operation cost effectively.

PayU

PayU is a leading online payment service provider dedicated to creating a fast and simple payment process for merchants and buyers. Used and trusted by some of the top eCommerce brands, we have and always will focus on matching merchants' needs with consumers' shopping and payments behaviour. Whether someone wants to make an electronic payment on a computer, tablet, mobile device, or even offline, our payment methods are designed to make it fast, simple and secure. PayU makes up the e-payments division of Naspers Ltd.

Peach Payments

Peach Payments provides payment solutions to online and mobile businesses enabling them to easily accept payments from consumers across the globe and especially from those in the emerging markets. They offer merchants a state-of-the-art payment solution with the most comprehensive product suite which enables them to accept payments across all their channels including their website, mobile site and their mobile apps (iOS, Android etc.).

Pocketslip

Turning paper into powerful digital connections between customers and retailers. Pocketslip has developed the world's first fully integrated digital receipt technology App that provides secure and live cloud-based storage of receipts and integrates with all POS systems. It is 'cost savings', 'CRM' and 'Green' rolled into one and it's free to the user. A customer shops at a Pocketslip enabled retailer and automatically receives their receipt on their email, app and online to use later on for warrantees, returns, tax and accounting.

Profitshare Partners PTY LTD

Profitshare Partners provides disruptive funding solutions and transaction support to SMEs who have no access to funding, no security, financials or track record, but have a contract or purchase order with a reputable company or government department. It responds within 24 hours, generates a term sheet within 48 hours and pays out within 7 days for new clients. The solution is a high impact growth tool for SMEs. There is no interest charged and it earns a percentage of the profit margin. It is a 100% end-to-end paperless solution and can service an SME.

Property Mogul

Property Mogul is a leading online, crowdfunding, capital markets platform within the traditional South African property industry. Using proprietary investment technology, they intend simplify the way people invest in South African real estate.

RainFin

RainFin's marketplace lending for corporate institutions is a first of its kind in South Africa. Corporate institutions can now obtain funding from RainFin's collective network of lenders. This means that lenders can now provide medium term loans to reputable, high quality established corporates, providing them with the same efficiency and flexibility to develop bigger enterprise opportunities, faster. RainFin enables small to medium businesses to get finance from a community of lenders. With a deeper understanding of a business' life cycle to succeed, we've designed a unique score card that takes a comprehensive look at a business' overall financial health, its future cash flow potential and general company creditworthiness. RainFin is the smartest way for businesses to obtain funding in a fast, efficient, cost effective and flexible way. RainFin's lending marketplace facilitates direct connections between creditworthy individuals, to borrow money from verified lenders at competitive interest rates and low fees. Borrowers receive loan offers from multiple lenders, who have the flexibility to choose which borrowers they want to lend money to.

Real Estate Crowdfunding Dotcoza

Real Estate Crowdfunding Dot CoZa – The Digital Ubuntu Real Estate Crowdfunding Dot CoZa is the first ever commercial real estate crowdfunding platform in South Africa. Our aim is to enable digital “Ubuntu”, and make commercial real estate investment within the reach of every South African. In the past, the majority of people were not able to participate in commercial real estate investments due to affordability and stringent lending criteria, yet this part of the real estate industry is one of the most lucrative. By bringing people together on a sharing and co-operating platform - which Real Estate Crowdfunding Dot CoZa aims to achieve - their buying power grows exponentially and many opportunities which were previously challenging or out of reach, now become possible.

Realty Wealth Holdings

RealtyWealth.com, a premium and powerful global real estate brand has achieved two firsts in the US real estate market. First portal to offer passive, institutional quality net lease (NNN) real estate investments

consisting of long-term lease, guaranteed by corporate backed Fortune 500 tenants and first portal to offer US-based Fortune 500 real estate investments to Foreign Investors in a response to growing investor demand for a fundamentally safe investment strategy.

Rehive

Rehive is the fastest and most affordable way to build, launch and scale fintech applications. When e-commerce scaled, Shopify opened up the doors for entrepreneurs to start online businesses. With the advent of mobile payments, cryptocurrencies and fintech in general, Rehive has built the most flexible, easy to use platform to attract entrepreneurs in like manner. However, fintech additionally attracts enterprises and even governments to participate in innovative ways of solving financial problems. Whether it's on a blockchain or on a locally hosted network, Rehive Platform is a business logic layer on top of any store of value that covers 60-80% of the requirements for almost any fintech use case. Rehive Platform caters for developers and managers alike. On the one side, managers have full transparency and control of user transactions using the back-office dashboard while developers have access to our API, open sourced projects and other resources for easily extending custom features where needed.

Riovic

A platform that connects low premium insurance seekers with investors willing to back their risk in exchange for return. Riovic provides an insurance market and P2P insurance service as its core business and various other financial technology-based services which include a financial management service and a payment gateway service.

22Seven

22seven can help people start over with their money. To see new things about it, get to know it better, keep it simpler, and grow it smarter.

Shepherd Financial Services

Shepherd offers an all-in-one, safe payment / logistics solution for C2C and B2C transactions. We bring trust back into online business by holding the buyer's money securely in a trust account and will only release once the buyer has inspected the goods and signed our courier waybill. They maintain control of the funds as well as the goods safeguarding both buyer and seller.

SID Instant EFT

Instant online eft payment method for South African e-commerce businesses. Hundreds of South African e-commerce businesses offer SID Instant EFT as a payment method on their websites, enabling them to receive secure online and mobile payments directly to their bank accounts. SID works by linking online shoppers to their secure Internet Banking, pre-populating the payment details and then directing them right back to the seller's website, where payment confirmation can be issued immediately. SID facilitates a seamless payment process on all devices, including smartphones and tablets. By implementing the SID payment method on their websites, businesses can now activate valuable online and mobile sales channels.

Smartdigital Solution

Smartdigital Solution offer next generation Cloud-based Core Banking Solutions that leverage on the interconnectness enabled by virtual networks.

Snapbill

SnapBill is a billing system that allows you to easily sell online. SnapBill is perfect for businesses requiring automated subscription or recurring billing with payment collection facilities. SnapBill fully automates both recurring credit card transactions and direct debit orders via a variety of payment gateways. SnapBill offers a comprehensive mix of invoicing, billing, client management and payment collection features.

SnapScan

SnapScan is an easy, affordable and convenient way for merchants to accept card payments, and a safe, secure and convenient payment method for users, who no longer have to carry cash around with them or worry about

their cards being skimmed. The app supports credit cards and most debit cards from any local bank, as well as 3D Secure-enabled international bank cards.

Stokfella (PTY) LTD

Stokfella is a solution for every stokvel to administrate and collectively unlock opportunities in group saving culture. StokFella uses the power of mobile technology to give the power to stokvels to efficiently pursue their dream. They provide all stokvels with a world class mobile solution that allows them to organise, manage, communicate, visualise and be more efficient in growing their wealth.

Strider

Strider uses smart technology for ready-to-go platforms that banks and financial institutions can rapidly white-label and present to market in order to stay relevant to the millennial, centennial, unbanked and underbanked markets.

Sureswipe

Sureswipe is a card payment acceptance organisation. Sureswipe offers independent retailers and service providers an easy and accessible way to accept card payments will aid in driving and sustaining their growth. With a recent surge of multiple payment methods and the disruption within the payments sector, they are strategically moving to consolidate payment channels in order to offer one point of contract and contact. Sureswipe is well positioned to simplify the administrative burden to independent retailers, while bringing efficiency and savings to the market.

The Sun Exchange

Through The Sun Exchange anyone on Earth can own solar panels powering African businesses and communities and earn a solar powered income equivalent to a 10% IRR. Their solar cell crowd-sale model democratizes solar energy finance. Their block-chain enabled platform autonomously distributes solar energy in real-time. Using digital currency to finance solar power, they are using silicon chips to finance silicon chips.

THISISME INC

ThisIsMe uses advanced multipoint identity verification and enhanced due diligence to reduce fraud and to ensure a seamless, on-demand KYC/FICA process for businesses and consumers.

Thundafund

Thundafund.com is a unique online channel through which people with great ideas can access capital, establish an initial market for their products/services and receive business/mentorship support. Thundafund.com initially focuses on projects with social, environmental or creative focus, widening this circle of impact as it grows. At its core, an online/mobile platform, Thundafund.com allows a large number of people to each invest small amounts into a project or idea. They are paid back with an 'in-kind' dividend produced through the project itself. These small amounts soon add up to the capital required, simply due to the crowd factor. In essence, the project creators, with their great idea, sell it before producing it.

TradeSafe

TradeSafe safeguards the Buyer's funds in the middle until the Seller delivers what was promised. TradeSafe, South Africa's longest running online financial escrow service, radically reduces the risk of fraud, scams and bad debt. It was established to protect consumers from the systemic rot that had encroached South Africa's commerce sectors. TradeSafe's platform is plug-and-play. Any online business can plug into its escrow methodology and architecture. A payment gateway coupled with an escrow flavour is the first of its kind in South Africa.

Tranzackt

Tranzackt is an online application that takes the handling of manual, paper-based documents and transfers it to the cloud (by making use of Digital Transactional Processing). All transactions processed through Tranzackt are immediately archived in our securely encrypted, online database for easy future retrieval, resulting in significant cost savings for your company.

Treasury Technologies

Treasury Consultants are experienced in all aspects of Treasury System Processes – from a big blue-chip company to smaller enterprises they have the experience and knowledge to implement world class TMS systems.

VCPAY

VCpay is the ultimate payment app that lets you create virtual credit cards for shopping online, in-app, over the phone or even to book a rental car. In just a matter of minutes you can sign-up, fund your FREE account and start transacting, safely and securely. When providing card information on any service, you're often worried about the risk that sharing these details will present. That's why VCpay is so awesome; it replaces your plastic card with an option that gives you total control over how much and how often any one card can be utilised for.

Veneka

Veneka has built and rolled out fintech solutions to promote inclusive access to financial services at low cost! Their technology is enabling Financial Services businesses to reach banked and unbanked consumers in over 30 countries in Africa. Financially included communities can bank, pay, send/receive money, save and borrow. Their agency and mobile banking technology breaks barriers of reach and cost for providers of financial services and underserved consumers of all segments. Accessing financial services anywhere, on any device, with any token, and from any provider is the goal of true Interoperability! They are pioneering interoperability in Africa through the Luminus platform.

Walletdoc

Walletdoc is the smart, secure & free way to pay bills - with no admin. Walletdoc lets you manage & pay your bills whenever, wherever. Walletdoc remembers account & reference numbers so you don't have to. Walletdoc stores your bills electronically for you.

Wallettec

Processing payments without sharing any personal or payment information with the merchant bypassing the card networks. For the first time in Africa, it is possible for businesses to process mobile money transactions at any Point of Sale. Wallettec is a SaaS (Software as a Service) platform that enables a retailer to accept any type of mobile transaction or currency type at their Point Of Sale. Through a single integration, retailers can enable consumers to transact at their Point Of Sale using only their mobile phones. No credit or debit cards required, no 3rd party apps. All you need is your mobile device and a bank account.

Wallettec turns mobile payments into a real solution and not only a fancy way to swipe your credit or debit card. With our solution all you need is your bank account and mobile device.

WAPPoint (PTY) LTD

WAPPoint is a mobile debit and credit card facilities provider that offers merchant services like no other.

Waxed Mobile Payments (PTY) LTD

Wax'd facilitates transactions between customers and merchants using the customers mobile phone as the payment device. The Wax'd user can directly link their bank account or load a wallet to enable payments. Using their mobile devices, Wax'd users can scan a QR code to trigger a transaction with a merchant. This includes scanning an advert on tv, a till point, on a table, or directly from a restaurant table. Wax'd aims to become the fastest, safest, cheapest and most convenient payment method in the world.

Wealth Migrate

Wealth Migrate is a leading global online investment marketplace that offers international investors direct access to exclusive real estate investment opportunities in premier markets, including the USA and Australia. Wealth Migrate partners with best-in-class developers and real estate investment companies, giving investors access to premier real estate opportunities. Wealth Migrate is well known for having spearheaded investment opportunities that were previously only accessible to wealthy institutions and high-net-worth individuals. Via

its breakthrough technology platform, the company has facilitated many investment opportunities to individuals who would previously not have had access to such large-scale real estate ventures.

WeChat Wallet

WeChat, Africa's fastest growing social communications platform has launched its WeChat Wallet. WeChat Wallet is a new way for you to manage payments with your mobile phone. You can add your debit or credit cards, get money sent to you from a friend and pay for goods and services at SnapScan merchants across South Africa. You can also buy airtime, electricity and any of the services in WeChat's growing ecosystem.

Wenapay

Wenapay is a secured universal AI predictive analytics temporary monthly payment gateway that allows users to send and receive money using any ATM of their or any online point of sales. With or without an actual bank account. Call it the soft Visa card.

Whozhoo

WhoZhoo allows consumers to 'connect with confidence' by using multiple trusted databases and multi-factor authentication to validate online identities. Not only does WhoZhoo address a burgeoning online crime problem, but stimulates economic activity by reducing the risk of buying, selling and generally connecting online. WhoZhoo subscribes fully to the provisions of POPI Act, and therefore only shares the contact information that would have been inherent in the online advert in the first place. All other authentication information is held in confidence, and accessible only to the data subject. Only individuals who have themselves been successfully verified, may request the verification of another individual. Requestors may purchase credits that allow them to invite others to verify themselves. at WhoZhoo, only the requester pays.

WI GROUP

wiGroup is a mobile transaction solutions provider with two core offerings; "wiCode", a point-of-sale integrated, open and interoperable, mobile transaction platform, and "wiBlox", an advanced suite of services which link mobile applications to mobile loyalty, rewards, vouchers, coupons and analytics functionality.

WIZZIT INTERNATIONAL

WIZZIT are regarded as leaders, global pioneers and innovators in Mobile banking and financial empowerment.

YOCO

Yoco focused on making card payment processes easier with an aim to help small businesses get paid, run the business better and grow it. Yoco allows you to accept card payments by turning your existing smartphone or tablet into a point of sale device. Our solution comprises of a mobile card reader, a point of sale App and Business Intelligence Portal.

Zapper

Zapper provides seamless all-in-one mobile payments, vouchering and loyalty services to a variety of businesses. They enable merchants to use data-driven insights to better engage their customers, build superior relationships and implement more targeted strategies to grow their businesses.

ZAR X

ZAR X is not only South Africa's first new stock exchange in 58 years. The ZAR X platform also makes it profitable for small to medium brokers to serve the vast and hitherto untapped retail market. It enables the average citizen to acquire a stake in business success with an investment as small as R1 000, massively expanding access to new exciting investment opportunities. While other exchanges are still at T+3 days, ZAR X's world leading platform enables settlement of trades in 10 seconds, de-risking transactions and reducing systemic risk.

ZIPZAP

ZipZap's philosophy is all about growing small businesses by giving them a mobile, cost-effective POS payment solution. ZipZap allows you to accept payment with a debit or credit card anywhere, any time.

Zoona

Zoona uses technology to provide financial services to people when they need them most so that communities can thrive. Entrepreneurs can access Zoona's platform from a mobile device, and use it to provide financial services like money transfers, payments, accounts and more.

Chapter 4: Support for FinTechs in South Africa

Three organisations emerged as providing support for the development of Fintechs in South Africa. They comprise the South African Reserve Bank, Alphacode which is the Rand Merchant Banks Incubator and the Startupbootcamp incubator programme.

The SARB recently established the Financial Technology (FinTech) Programme to strategically assess the emergence of FinTech in a structured and organised manner, and to consider its regulatory implications. The main goal of the programme is to track and analyse FinTech developments and to assist policymakers in formulating frameworks in response to these emerging innovations.

The FinTech Programme will focus on three primary objectives:

- The first objective is to review the SARB's position on private cryptocurrencies to inform an appropriate policy framework and regulatory regime. This review will address regulatory issues such as clearing and settlement risks, exchange control impacts, monetary policy and financial stability, and other matters such as cybersecurity considerations. Through collaboration with the other regulatory bodies, matters such as tax implications, consumer and investor protection, and money laundering activities will also be addressed.

- The second objective is to investigate and decide on the applicability of innovation facilitators for the SARB. 'Innovation facilitators' is a collective term for innovation hubs, regulatory sandboxes and accelerators. The

  SARB hopes to have concluded its assessment of the appropriateness of innovation facilitators by the third quarter of 2018. Clear and transparent eligibility and participation criteria will be developed to assist in the consideration of applicants into a regulatory sandbox.

- The third objective is to launch Project Khokha which will experiment with distributed ledger technologies (DLTs). The aim of this project is to gain a practical understanding of DLTs through the development of a proof of concept (POC) in collaboration with the banking industry. The objective of the POC is to replicate interbank clearing and settlement on a DLT which will allow the SARB and industry to jointly assess the potential benefits and risks of DLTs. The POC involves the processing of wholesale payments using Quorum, an Ethereum enterprise DLT. The SARB is aware of multiple DLTs being experimented with globally.

These initiatives aim to assist in the formulation of appropriate policy frameworks for the possible regulation of FinTech.

AlphaCode is the Rand Merchant Investments (RMI) incubation, acceleration and investment initiative that identifies, partners and grows early stage financial service ventures. The entrepreneurial packages consist of R1 million in grant funding and R1 million in support, which includes mentorship, monthly expert-led sessions, exclusive office space in Sandton, marketing, legal and other business support services as well as access to the broader RMI network. The packages are part of the AlphaCode Incubate initiative, which is done in partnership with Merrill Lynch South Africa and Royal Bafokeng Holdings. The project identifies South African financial services entrepreneurs with extraordinary ideas and businesses that could impact the financial services industry.

More than 200 startups applied to participate. Of these, sixteen made it to final pitch evening and eight recipients were selected. During the event, contestants had just three minutes to pitch their businesses, with a couple of minutes set aside for questions from a panel of judges.

Startup	Description
Akiba Digital	A gamified mobile app making it easier and more rewarding to set, manage and meet savings goals.
iSpani Group	Provides access for insurers into traditionally under insured communities through prepaid vouchers and USSD sold by a network of spaza shop vendors.
Jamii	De-risks tenant rent default through offering tenants incentive-based discounts on food and transport and bolt-on retrenchment cover.
Nisa Finance	An invoice financing platform that enables financiers to issue invoice-backed loans to SMEs quickly and affordably by fully-automating the application and invoice verification through ERP system integration.
Pago	A low cost mobile micro payments platform for the informal sector to enable an inclusive economy by digitising remittances through the use of blockchain technology.
rospa	A mobile savings wallet for low-income earning South Africans that makes it easy to save small amounts infrequently using prepaid vouchers.
SELFsure	Enables millennials to significantly reduce car insurance premiums by self-insuring part of the risk via peer to peer lending.
Yalu	A self-service credit life insurance platform which replaces a customer's current policy with a more affordable, simpler and rewarding policy.

Startupbootcamp was founded in 2010 in Copenhagen with a core mission of supporting the world's best entrepreneurs through al stages of their development. This global industry-focused accelerator group has 18 programmes across 13 countries and has seen value in now setting up a footprint in Africa. Startupbootcamp Afritech is a leading accelerator focused on high-growth startups in blockchain, connected devices, payment solutions, capital markets and asset management, integrated supply chain, e-commerce, retailtech, insurtech, alternative financing, identity management, digital connectivity, data and behavioral analytics and enabling technologies.

The aim is to grow disruptive startups and connect them with dynamic corporates, providing both with an opportunity to collaborate and build the **African tech ecosystem**. For its first round in 2017, Startupbootcamp

Cape Town selected 10 most promising teams, and provided each team with 15 000 euros, 100+ highly engaged mentors from the FinTech, InsurTech and RegTech industries, free office space, a convertible note, access to funding and a network of industry partners, investors and venture capital firms. The accelerator is anchored by leading corporate sponsors Old Mutual, RCS, BNP Paribas, Nedbank, and PwC. Global sponsors include Amazon Web Services, and Cisco.

The South African Reserve Bank (SARB) and the Financial Services Conduct Authority (FSCA) will establish an innovation hub for the regulation of fintech or innovative financial products in the first half of 2020.

The hub will include:

- A regulatory guidance unit – a platform where financial institutions and fintech providers can engage with regulators for guidance on these new products and services. It will provide formal guidance engagement for fintech companies that need to understand the regulatory landscape and act as a tool for regulators to keep abreast of innovation in financial services.

- Regulatory sandbox – this will allow innovators to test their fintech products in a 'live' environment with specific regulatory relief. For example, the innovator may test a specific product with 100 clients over a three-month period. SARB and the FSCA will have oversight of the process and will use the information gathered to guide any regulatory actions that may need to be introduced.

Conclusion

This desktop research provides the baseline for further research on fintech companies. Using the telephonic interview methodology, each of the listed Fintech companies will be interviewed to source further data to guide the kind of support these companies need to grow and compete globally. In addition, there seems to be a need for a Fintech Incubator support programme. A possible collaboration with the South African Reserve Bank and the Big Banks in South Africa may be the best way forward. Further research is required to build a business case for the Fintech Incubator programme.

References

https://www.computerworld.com/article/3225515/what-is-fintech-and-how-has-it-evolved.html accessed 20 June 2019

https://businesstech.co.za/news/internet/278399/8-hot-new-south-african-fintech-startups-to-watch/ accessed 20 June 2019

https://businesstech.co.za/news/banking/281121/this-south-african-fintech-company-ranks-among-the-most-innovative-in-the-world/ accessed 20 June 2019

https://www.iol.co.za/personal-finance/opinion-south-african-fintech-in-2019-what-can-we-expect-18807778 accessed 20 June 2019

https://www.resbank.co.za/Lists/News%20and%20Publications/Attachments/8259/SARB%20FinTech%20release%2013%20February.pdf accessed 20 June 2019

TITLE OF RESEARCH	Investigate the extent of alignment of the PSET system to the supply of skills relevant for the Fourth Industrial Revolution (digitalisation). This must include the hosting of Insight Workshops with all relevant stakeholder groups and prepare a Final Report
CONTRACT NUMBER	***475.4710.644***
START DATE	***05 October 2018***
END DATE	***28 February 2020***
TRANCHE TWO	• ***Desktop Research Report***
Version	***001***

Approval and Sign-off

_____ **30 June 2019**

DUT _____

(Date)

_____ _____

Head of Research: BANKSETA **(Date)**

Chapter 1: Background to the Study

This study focuses on the alignment of the Post Schooling Education and Training (PSET) system to the 4IR industrial revolution. This study investigates and assesses the adeptness of PSET system to prepare graduates for the 4th industrial revolution and the skills demand thereof. The PSET system in South Africa is comprised of Universities, Universities of Technology (UoT's) and Technical and Vocational Education and Training (TVET) Colleges. The Fourth Industrial Revolution can be defined as a period characterised by the convergence of cyber, physical and biological worlds and one where new and emerging technologies is prevalent in every aspect of our lives.

Since the turn of the 21st century, the increase in new and emerging technologies and the impact of such technologies across the globe is becoming more apparent. If time travel was possible, our fore-bearers would find our current socio-political, sociocultural and socioeconomic milieu quite strange. In the context of assessing the supply of relevant skills to the current Fourth Industrial Revolution, it can be said that the changing dynamics of work today was unfathomable just a few decades ago. Machines have taken over some jobs that humans thought could only be done by them, and more women now work and are breadwinners of their families today than they were five decades ago. Schess (2013) aptly captures the immense change that has taken place in the workplace, and in the nature of workers over the last few decades: "…In 1983, the workplace was, technologically speaking, a very different place. There was no e-mail,' no texting, and no instant messaging….Yet, with the advent of modern technology, the edges of compensable "hours worked" have blurred. (Schess, 2013). Although Schess' views were from the standpoint of the legal profession, chances are if the information were posted on other job areas, they would still find relevance.

The changing world of work since the advent of the Fourth Industrial Revolution is not an entirely new phenomenon in itself. It is important to note that each successive industrial revolution has had, as the name suggests a disruptive influence, in the manner that society worked, travelled, communicated, and lived. In the short term each revolution brought an initial carnage to the job ecosystem taking away thousands of jobs. The tractor took away thousands of ploughman jobs, the internet all but eradicated the role of the postman with a more recent casualty being the print media such as newspapers, while word processors replaced typing pools. Over time repetitive, so-called semi-skilled jobs have disappeared and new systems emerged. However, in current era, work in the context of 4IR is driven by the convergence of the cyber, physical and the biological realms. Industry 4.0 is now characterised by exponential technologies including artificial intelligence (AI), augmented and virtual reality (AR and VR), data science, digital biology and biotech, medicine, nanotechnology

and digital fabrication, cloud, networks and computing systems, robotics, and autonomous vehicles. In this regard, the Fourth Industrial Revolution makes a significant departure from other Industrial Revolutions in that these emerging technologies require multi-disciplinary and interdisciplinary knowledge and skills.

Moreover such technologies provide greater impetus and opportunity for schools and tertiary institutions to re-design the curriculum to meet the needs of 4IR and Industry 4.0. Academics, politicians and practitioners alike have underscored the importance of adapting our education system to adequately prepare graduates for the Fourth Industrial Revolution and Industry 4.0. Former Minister of Higher Education, Dr Naledi Pandor placed emphasis on this when she noted that "If we intend to take full advantage of 4IR, all our universities and colleges should be offering such courses," (Mzekandaba, 2019).

According to Professor Marwala of the University of Johannesburg "as the digital age transforms the way in which people live, it will also have an impact on the economy and on jobs. New trades with new skills will be created and some jobs that are currently being done by humans will be replaced by automated systems." (Chauke, 2018) Indeed, as our industries are transmuting to embrace 4IR technologies, the skills demand spawned by the 4th industrial revolution is becoming more eminent. The skills of 'yesterday' are increasingly becoming 'obsolete' today. Sadly, most tertiary institutions still run curriculums that were designed for the 3IR, in fact, some curriculums predate the 3IR. Hence there needs to be a merging of technology and pedagogy in order to meet the demands of the 4IR. It is in this context that we foreground the relevance of this study to assess the readiness of the PSET landscape to meet the rapidly changing needs of a 4IR economy.

Chapter 2: Research Process

Qualitative methodology is the primary research method that guided the development of this desktop report. For this desktop study, secondary research data collection and data analysis was conducted. This included:

- a literature survey of academic articles/ journals relevant to the 4th industrial using key words/ phrases such as: '4th industrial revolution and skills demand'; 'Industry 4.0 and new and emerging technologies'; 'adapting education systems for the 4th industrial revolution'.
- A literature survey of Government gazettes relevant to the PSET system specifically: National Skills Development Plan (NSDP); Occupations in High Demand were also consulted.
- A literature survey of key economic reports such as the World Economic Forums 'Future of Jobs' report were consulted in assessing the impact of 4IR on industries and GDP growth globally.
- A review of online articles to assess public opinion on 4IR and skills alignment in South Africa and globally were consulted.
- Searches of websites of institutions of higher learning in South Africa were undertaken to generate a table of courses offered at South African universities that are relevant to 4IR.

The above sites/ journals/ articles, government gazettes and organisational reports were conducted with the aim of responding to the following research questions:

1. What technologies are changing in industry in line with the industry clusters used for GDP statistics?
2. What are the broad skills required in the 4IR for each industry cluster?
3. What are the courses, subjects and programmes that are offered at universities and Universities of Technology that produce graduates that work in the 4IR space?

A comprehensive response to the above research questions from the standpoint of the available literature is provided henceforth in this report. Primary research data collection and analysis is a separate deliverable that will be conducted in the form of focus groups and insight workshops. Primary research methodology will be applied to respond to the following research questions:

3. What are the courses, subjects and programmes that are offered at universities and Universities of Technology that produce graduates that work in the 4IR space? (This has been partially responded to through desktop research)
4. What are the gaps in the TVET curriculum and what skills will be required by lecturers to meet the training needs of industry in 4IR?

A more contextualised report focusing on the above two research questions in the South African context will be provided in the next research report. This will include primary research data collection and analysis and focus

group interviews with Universities, Universities of Technology and TVET Colleges as proposed in the Master Research Plan.

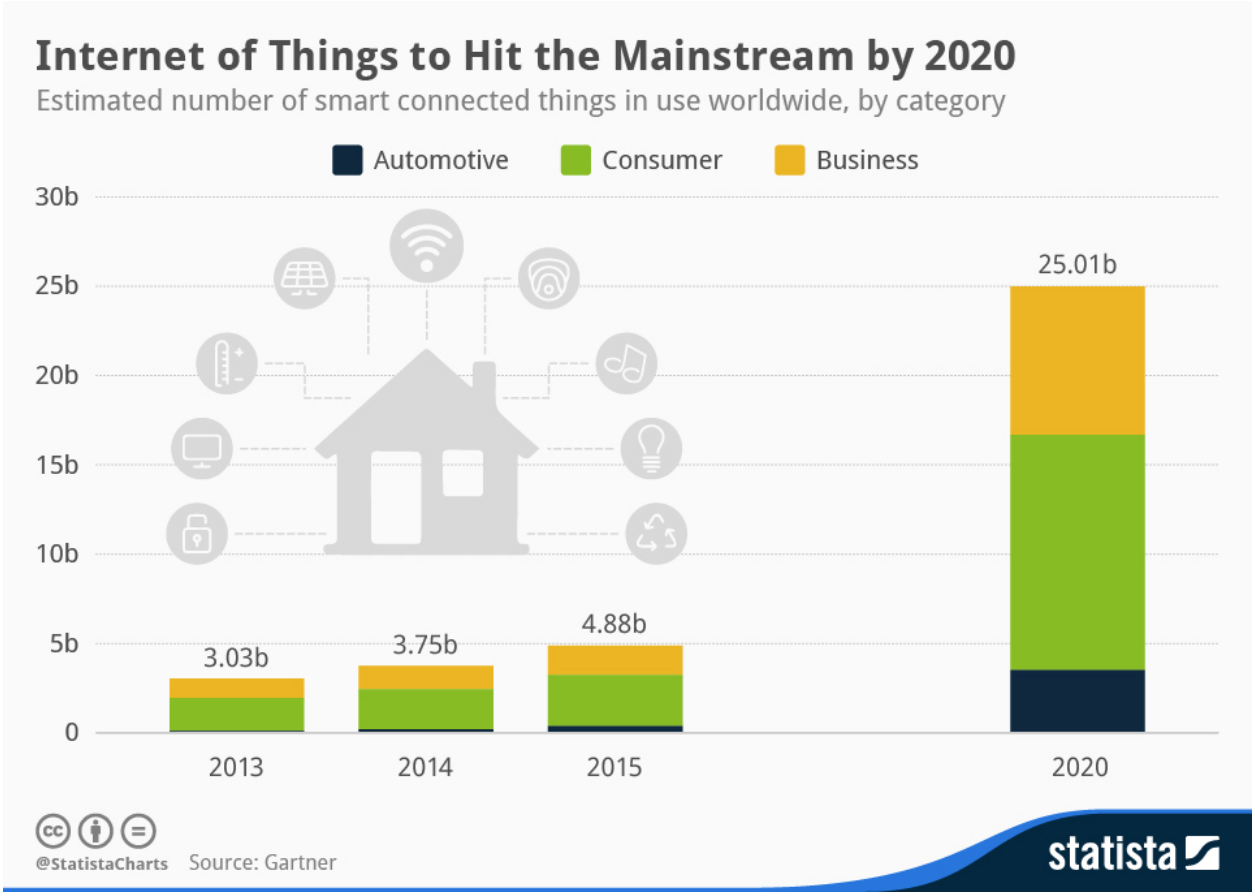
Chapter 3: Demand of the fourth industrial revolution on the skills system

3.1 The Transition from Industry to Industry 4.0

The aforementioned 4IR technologies, namely, artificial intelligence (AI), augmented and virtual reality (AR and VR), data science, digital biology and biotech, medicine, nanotechnology and digital fabrication, cloud, networks and computing systems, robotics, and autonomous vehicles are now being adopted by industry. Most businesses are facing challenges in dealing with big data issues of rapid decision-making for improved productivity. This may be attributed to the dearth of analytical tools for the management of big data (Lee, Kao and Yang 2014). More concerning is that social economic factors such as lack of skilled workforce, and aging population have become problematic for today's business environment (Lee, Kao and Yang 2014). As a consequence, companies are beginning to change and align their business model and organizational structure to accommodate the rapid transformation in the digital era. By harnessing of 4IR, organizations are now effortlessly improving the standard of living of people by providing customized and high-quality products to consumers (Waibel *et al.* 2017). This section reviews key 4IR technologies as it is applied and utilized in industry.

- *Internet of Things (IoT)*

According to Xia *et al.* (2012), the internet of things (IoT) is an inter-networking world where various objects are embedded with electronic sensors, actuators, or other digital devices which primary purpose is to collect and exchange data. Hence, the IoT offer an advanced network connectivity of both physical objects, systems, and services thereby promoting object-to-object communication and data sharing (Zhong *et al.* 2017). Of interest, and as highlighted in the World Economic Forum (2019) report, more than a trillion sensors is expected to be connected to the internet in the next decade. It can therefore be assumed that when everything is connected, it will transform how we do business and help us manage resources more efficiently and sustainably. Equally essential, the connected sensors will be able to share information from their environment and organise themselves to make our lives easier and safer. It is assumed that self-driving vehicles, for example, could "communicate" with one another, preventing accidents. By 2020 around 22% of the world's cars will be connected to the internet (290 million vehicles), and by 2024, more than half of home internet traffic will be used by appliances and devices (Figure 2).



1.1.2 Big data

With the advent of internet and the push towards information technologies worldwide, people are now leaving trails of data which have become more accessible and complex for many businesses. This has consequently resulted to big data (Manyika *et al.* 2011). According to the report by Rich (2012), big data could emanate from sources such as sensors, devices, video/audio, networks, log files, transactional applications, the web, and social media feeds. As highlighted in Table 2, big data analytics is now widespread in multiple industries. It can be gathered from the Table 2 that it is not just internet giants like Google or giant retailers such as Tesco that have benefited from big data analytics. In fact, Fedak (2018) hinted that organisations from the banking and financial services to healthcare and government have depend on the analytics of big data. This strongly reinforce the earlier assertion made by Zhong *et al.* (2017) that there are numerous applications of big data analytics from e-commerce companies and financial investment institutes.

Table 2: Industrial clusters of big data analytics applications

Industries/Countries	Main purpose
Google, USA	•Refining its core search and ad-serving algorithms
Retailers, UK and USA	•Tesco: precise promotions and strategic segmentation of customers •Amazon: accurate recommendations for customers •Wal-Mart: supply-chain optimization
Biopharmaceutical industry, USA	•Reducing process flaws •Eliminating yield variation
Remote monitoring application for heavy-duty equipment vehicle, USA	•Assessing and predicting the health of the diesel engine component
Tata Motor, India	•Driving quality and reducing cost in manufacturing process • Increasing customer satisfaction level
Premier Healthcare Alliance (vendor: IBM), USA	•Improving patient outcomes • Reducing expenditure
General Electric (Global Software and Analytics Center), USA	•Boosting industrial product sales • Reducing after-sale maintenance cost
Aerospace industry, USA	•Predicting number of returns in the future •Minimizing product escapes

- *Cloud computing*
- Several reported studies (Xu 2012; Hashem *et al.* 2015) refers to cloud computing as the delivering computational services for many users over the Internet. Moreover, cloud computing is one of the key features of the 4IR concept, as it allows the flexibility and scalability of business (Zhang, Cheng and Boutaba 2010). Given the effectiveness of cloud computing for businesses, it is no surprise that its application (Table 4) ranges from healthcare to education to transportation and manufacturing (Zhong *et al.* 2017).

Table 4: Cloud computing application in clusters industries

Industries/Countries	Main purpose
Business, France	Proposing a method for cloud business applications
National Natural Science Foundation, China	Presenting a hybrid information fusion approach
Business and healthcare, UK	Developing cloud computing in the life sciences
IT and business, UK	Highlighting aspects and uniqueness of cloud computing
Manufacturing, Iran	Proposing a service-oriented approach
Education, India	Outlining the benefits of using cloud computing for students
ICT, China	Proposing a forensic method for efficient file extraction
ISO-New England, USA	Developing cloud-based power system simulation platform
Transportation, China	Formulating a new entropy-cloud approach

- 3-D Printing
- 3D printing is a process of creating three-dimensional solid objects based on digital schematics, and thus could be considered a relatively emerging technology that is rapidly gaining much ground in the 21st century (Long *et al.* 2017). Xu *et al.* (2018) revealed that 3 D printed objects are created using additive processes and putting down successive layers of materials until the entire objects are created. As a consequence of this unique mode of production, 3-D printing had find numerous usefulness applications in various industrial clusters including automobile, architectural designs, aerospace, industrial machinery, healthcare, consumer products, defense, and has also become a subject of several academic research (Dodziuk 2016; Xu *et al.* 2018).
- Whilst 3 D printing is often viewed as a futuristic technology (Choonara *et al.* 2016), China, for example, were already researching on 3 D printing in the early 1990s (Xu *et al.* 2018). Caffrey and Wohlers (2015) in their annual reports revealed that China is ranked third in the world in terms of the total number of industrial 3D printing systems, thus accounting for 9.2% of total global installations. According to the

report published in the Journal Popular Science, in 2014, doctors in China gave a boy a 3D printed spine implant (Fedak 2018).

- *Cyber-Physical Systems*

Cyber-physical system [CPS] is described as the connection and communication between software components and mechanical and electrical parts through wired or wireless data infrastructure like the internet (Waibel *et al.* 2017). Essentially, it is sufficient to assume that CPS is a fusion of the physical and the virtual worlds (Guerrieri *et al.* 2016; Chen, Ho and Chiu 2017). According to the claim made by Waibel and his co-authors, CPS had made it possible to monitor and steer production system in a very effective way (Waibel *et al.* 2017). Particularly, and to ensure the sustainability of manufacturing sector, networking of cyber-physical equipment and machinery could be essential as a response to the growing production requirements (Waibel *et al.* 2017). This is particularly useful to create a smart factories where worker are not required to run routine task (Waibel *et al.* 2017). Consequently, it is assumed that direct communication will become minima in some specific areas due to the ability of cyber physical systems to communicate with each other (Waibel *et al.* 2017). For this reason, many industries have initiated projects in the CPS domain (Zhong *et al.* 2017). For example, it is reported that Festo Motion Terminal makes full use of an intelligent fusion of mechanics, electronics, embedded sensors and control, and software/applications (Digital pneumatics 2017). Other notable applications of CPS can be found in Table 5. It can be gleaned that the advances of CPS had gained tremendous effects on many fields, including medicine and healthcare, biology, civil structures, autonomous vehicles, intelligent manufacturing, and power distribution.

Table 5: Industrial clusters of CPS application

Industries/Countries
Power systems, USA and Canada
Children keeper service, Korea
Water distribution networks, USA
Civil structure, USA
Fire handling. China
Autonomous vehicles, USA and Germany
Intelligent manufacturing, Sweden and USA
Healthcare, Brazil

As is evident from the above examples, 4IR technologies are now being utilized in various industries ranging from Healthcare to Transportation. The remarkable benefits of 4IR, particularly in the automation of traditional industries have attracting increasing investments from both governments and industries around the world. Although the complexities and intricacies of 4IR technologies are still in the embryonic stage of development and more futuristic, the broad scope of their potential applications have become increasingly important in today's industrial sectors. Thus, this has consequently offers great opportunities for multidisciplinary collaboration amongst industrial experts, computer scientist and engineers (Zhong *et al.* 2017). Moreover, countries, particularly the developed ones like USA and Germany as well as emerging economy like China have invested heavily and developed strategy for maintaining competitiveness in the global economy. This section we now review some of the strategic plans and projects around the world in the context of 4IR and Industry 4.0.

3.1.1 Germany Industrie 4.0

Germany is a leading country driving the 4IR transformation code named (Industrie 4.0). As highlighted in the European Union report on digital transformation (European Commission 2017), Industrie 4.0 is a national strategic initiative from the German government through the Ministry of Education and Research (BMBF) and the Ministry for Economic Affairs and Energy (BMWI). The concept of industries 4.0 was proposed in 2011 and officially launched in 2013. Accordingly, the Industrie 4.0 strategic plan is pursued over a 10-15-year period and is based on the German government's High Tech 2020 Strategy. According to (Kagermann, Wahlster and Helbig 2013), the strategic aim of the Industrie 4.0 was to create manufacturing industries occupied by intelligent machines and products where intelligent systems and networks are able to communicate with each other independently. This is also reflected in the statement made by the German Chancellor, Angela Merkel on the strategic plan for Industrie 4.0.

"We must (…) deal quickly with the fusion of the online world and the world of industrial production. In Germany, we call it Industrie 4.0." –

Given that Germany manufacturing industry is known for its excellent quality products, part of the strategic goal of the Industrie 4.0 was to maintain the competitiveness of their product through research support, the networking of industry partners, and standardization. In an attempt to achieve the Industrie 4.0 strategic

mandate, the Germany government is focusing on research into the underlying technologies for manufacturers such as intelligent sensing, wireless sensor networks, and CPS (Zhong *et al.* 2017). Table 1 gives an overview and step by step strategic plan of the Industrie 4.0. It can be gathered that the German government had opted for a mixed funding model which include public and private partnership to drive the strategic plan. Although the convener of the Industrie 4.0 BMBF and BMWI have jointly allocated €200 million in funding (European Commission 2017).

Table 1: Overview of Germany Industrie 4.0 strategy

Main points:	Content
Policy lever (s)	Publicly-backed and steered initiative that is implemented through stakeholder dialogue
Funding Model	Mixing public funding with private financial and in-kind contributions; offering between a two to one or five to one ratio between private to public investment
Target Audience	Manufacturers/producers, SMEs and policy-makers
Impact & Focus Areas	Digital innovation and ICT market; transformation of business models and product/service delivery
Key drivers	Idea development by research actors, reform experience in production and pro-active unions
Key barriers	Competition among leading ICT players and shop-floor-level involvement
Implementation Strategy	Comprehensive research agenda and I40 platform as a network foundation for digital transformation
Results Achieved	Reducing industry segregation, transforming research agenda into practice, developing

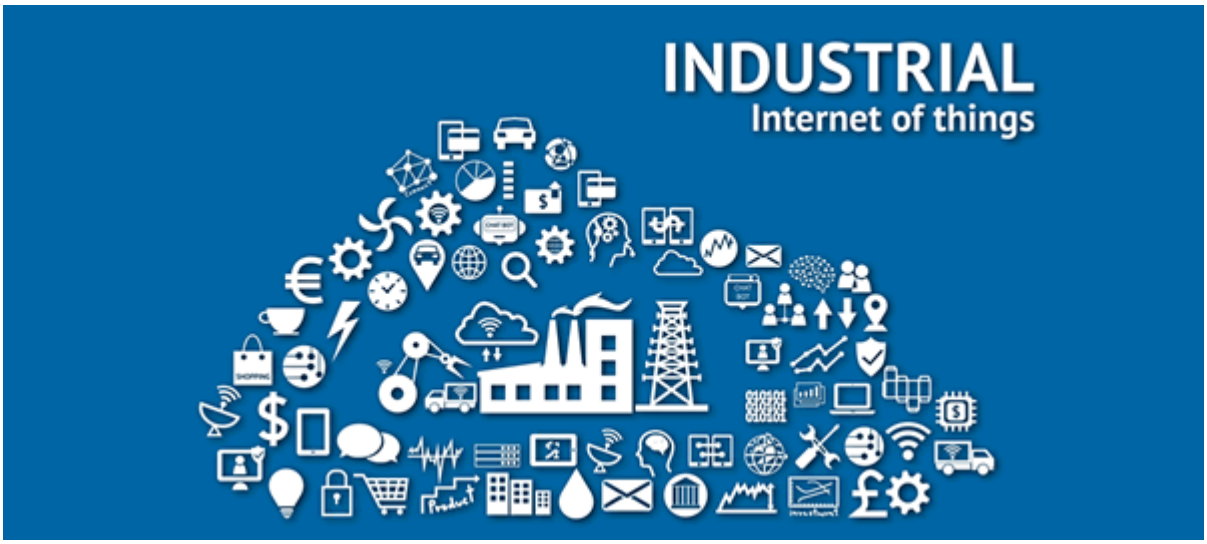
	reference architecture and launch of platform with 150 members
Budget	EUR 200 million from BMBF and BMWI that is complemented by financial and in-kind contributions from industry
Uniqueness Factor	Rapid transformation from research agenda into mainstream practice and platform constitute the largest and most diverse I40 network globally
Value added for policy-markers	A strategic initiative for consolidating technological leadership in mechanical engineering and for helping policy-makers to push forward I40 at all levels
Expected impact	Provide a consistent and reliable framework for developing Germany's competitive position in manufacturing through recommendations and actions

3.1.2 European Union

The European Union had also launched her own imitative termed Horizon 2020 that is tailored to the Industrie 4.0 (Horizon 2020 2017). Of interest, Horizon 2020 is biggest ever research and innovation program, with an estimated €75 billion of funding available over seven years (2014–2020). Under Horizon 2020, the new contractual public-private partnership (PPP) on Factories of the Future (FoF) will build on the successes of the European Union's 7th Framework Program for Research and Technological Development (FP7 2007–2013) FoF PPP. The FoF multi-annual roadmap for the years from 2014 to 2020 sets a vision and outlines routes toward high added-value manufacturing technologies for the factories of the future, which will be clean, high performing, environmentally friendly, and socially sustainable.

3.1.3 The USA

The USA strategic plan could be viewed from the lenses of the industrial internet of things (IIoT) introduced by the GE in 2012. According to the report by Evans and Annunziata (2012), the three major components of the Industrial Internet are intelligent equipment, intelligent systems, and intelligent decision making (Evans and Annunziata 2012). In paving a way forward to achieving this, the Industrial Internet Consortium (IIC) was formed in 2014 to provide a more robust resources, ideas, pilot projects, and activities about IIoT, particularly the security of these emerging technologies (Industrial Internet consortium 2017). As such, IIC had support of big USA brands like GE, AT &T, Cisco, Intel, and IBM. Moreover, Zhong *et al.* (2017) moots that with a network of machines, materials, workers, and systems, the IIoT will ultimately achieve the smart factory in Industry 4.0. In addition, innovative IT technologies such as cloud computing, virtual reality, and big data is of particular importance to the United States policy in driving their perceived dominance in the 4IR (Posada *et al.* 2015).



3.1.4 Made in China

The Made in China strategy was introduced by the China's State Council in May 2015. The strategy has a 10 year plan (2016-2025) that is aimed to upgrade the countries manufacturing capacity in order to match other notable economy powers such as the USA and Germany (Zhong *et al.* 2017). Hence, the Made in China could be considered as China's version of industries 4.0. According to the report by Li (2018), the blue print for the plan was developed jointly by China's National Development and Reform Commission (NDRC) and by the

Ministry of Science & Technology (MOST), with additional inputs from the Ministry of Industry and Information Technology (MIIT) and other constituencies. Interestingly, China has a more ambitious plan that seek a world dominance in the digital era and "Made-in-China 2025" is the first-stage of a "three phase" grand plan. According to some report, the core objective of this plan is to see China become a world manufacturing power from the current grand production workshop of the world. Thus, the plan focuses on improving the quality of products made in China, creating China's own brands, building a solid manufacturing capability by developing cutting-edge advanced technologies, researching new materials, and producing key parts and components of major products (Li 2018).

Accordingly and to meet the strategic goal of the plan, the State Council of China has pinpoint and prioritized 10 critical areas to roll out the plan. These includes:

- next-generation information technology,
- high-end numerical control machinery and robotics,
- aerospace and aviation equipment,
- maritime engineering equipment and high-tech maritime vessel manufacturing,
- advanced rail equipment,
- energy-saving and new energy vehicles,
- electrical equipment,
- agricultural machinery and equipment,
- new materials, and
- biopharmaceuticals and high-performance medical devices.

Furthermore, the proposed plan also seeks to establish 40 manufacturing innovation centers by 2025. Hence, the Chinese government has also proposed some specific strategic plans in order to support their ongoing manufacturing transformation. These include: Guidance of the State Council on Promoting Internet+ Action, Guidance of the State Council on Deepening the Integration of Manufacturing and the Internet, and the 13th Five-Year Plan on the National Program for Science and Technology Innovation (Wang *et al.* 2016).

3.2 Changing Skills Requirements in the Context of Industry 4.0

This section briefly reviews some key skills requisites and capabilities that current and future employees or graduates will need to possess if they are to continue to work in industries that are technologically inclined towards the 4th industrial revolution.

The 2018 Future of Jobs report conducted a survey of the adoption of 4IR technologies per industry cluster (Table 1). (World Economic Forum, 2018: 16) From a quantitative perspective, this report reveals that there has been a strong uptake of 4IR technologies per industry cluster globally. The report notes that the uptake of new and emerging 4IR technologies such as robotics "is set to be adopted by 37% to 23% of the companies surveyed in the report" (Future of Jobs Report, 2018: 15). With reference to the Financial Services and Investors industry, the report mentions that Distributed Ledger technologies are set to have a significant impact as 73% of respondents expect their enterprise to adopt its use. (Future of Jobs Report, 2018: 15)

Table 5: Technology Adoption by Industry and share of companies surveyed (2018-2022) (Future of Jobs Report, World Economic Forum 2018: 16)

Technology	Overall	Automotive, Aerospace Supply Chain & Transport	Aviation Travel & Tourism	Chemistry, Advance Materials & Biotechnology	Consumer	Energy Utilities & Technologies	Financial Services & Investors	Global Health & Healthcare	ICT	Infrastructure	Mining & Metals	Oil & Gas	Professional Services
User and entity big data analytics	85	84	89	79	85	85	86	87	93	65	62	87	85
App- and web-enabled markets	75	76	95	71	88	65	89	80	93	53	50	61	74
Internet of things	75	82	95	58	73	85	65	67	86	76	50	83	74
Machine learning	73	87	79	58	82	77	73	80	91	53	69	70	74
Cloud computing	72	76	79	67	67	73	65	73	91	71	62	78	76
Digital trade	59	68	68	62	82	58	70	53	70	47	50	57	59
Augmented and virtual reality	58	71	68	50	48	65	59	67	72	59	62	65	53
Encryption	54	58	53	25	42	38	73	67	67	41	25	57	53
New materials	52	71	32	79	79	65	22	60	30	82	62	83	41
Wearable electronics	46	61	53	46	45	42	49	73	49	24	25	70	35
Distributed ledger (blockchain)	45	32	37	29	39	54	73	67	67	18	38	48	50
3D printing	41	61	21	58	42	54	19	53	35	41	50	57	29
Autonomous transport	40	74	58	54	39	46	16	20	44	41	50	30	41
Stationary robots	37	53	37	50	42	35	27	47	35	35	38	52	29
Quantum computing	36	29	32	25	33	46	43	33	44	24	19	43	41
Non-humanoid land robots	33	42	26	21	36	27	32	40	37	29	25	30	24
Biotechnology	28	18	0	42	52	42	11	87	23	12	44	39	24
Humanoid robots	23	29	26	17	18	8	35	13	33	12	25	13	24
Aerial and underwater robots	19	18	16	17	12	35	5	0	19	29	25	52	21

As indicated in Table 5, the uptake of new and emerging technologies inevitably leads to new skills demand in these industries. The literature on 4IR technologies and its application in various industries illustrates two major trends in terms of the demands placed on skills system. The first major trend stems from an academic perspective wherein the literature demonstrates that traditional education systems that focus on homogenous learning programmes is no longer sufficient in the era of 4IR. (Pillay & Maharaj, 2018; Anderson-Cook et al. 2019; Sackey

& Bester, 2016; Prisecaru, 2016) In their study on artificial intelligence and its role in engineering and computer science, Pillay & Maharaj note that "while artificial intelligence has generally been perceived as a computer science discipline as we move into the fourth industrial revolution it is clear that it is becoming interdisciplinary". (2018: 01) King et al. (2017) examine the probability of tax and job losses as a result of artificial intelligence and machine learning. They note that "computer courses may need to become compulsory for students young and old so that future employees are capable of working alongside robots". (King et al, 2017: 61) Specifically, they emphasize the need for more computer-related courses such as computer science, coding and encrypting, engineering and many other technology-related areas. (King et al, 2017: 61)

Sackey & Bester (2016) conducted a study on industrial engineering curriculum enhancements required for Industrial Engineers to acquire necessary skills to be proficient in an Industry 4.0 setting. Their findings revealed that industrial engineering curricula must now consider modules in Big Data Analytics, advanced simulation and virtual plant modelling, Data communication and networks and system automation, Digital-to-physical transfer technologies, such as 3-D printing amongst other 4IR emerging technologies in order to advance the industrial engineering discipline into the age of Industry 4.0. (Sackey & Bester, 2016: 107-108) From the above studies, we can infer that in order for graduates to be proficient in new and emerging technologies, the broad skills needed are underpinned by capabilities in statistics, mathematics, computer science and IT. Without these basic capabilities amongst our workforce and graduates, Industry 4.0 will not be sustainable as there will be a lack of skill personnel to operate, coordinate and manage systems that utilise 4IR technologies.

Furthermore the literature emphasizes that interdisciplinary and multidisciplinary collaboration is fundamental in the 4th industrial revolution. With reference to the field of statistics, Anderson-Cook et al. (2019) propose that interdisciplinary collaboration among statisticians and subject-matter experts in other disciplines is necessary in order to provide innovative and creative solutions in decision-making and problem-solving. Although Anderson-Cook et al. (2019) do not make specific reference to the 4th Industrial revolution, their hypothesis for the discipline of statistics is relevant to the collaborative nature of the skills needed for Industry 4.0. In his public lecture to the University of Pretoria, Dr Gustav Rohde stated that "Engineering practitioners will have to consider psychology (how people think, act, decide and behave), sociology (how groups interact), communications (how engineering solutions are communicated), and ethics (understanding the social and economic impact of their solutions). (Public Lecture, 2018) Therefore another key feature of the nature of skills relevant to the 4th Industrial Revolution is that industries, even those in the conventionally 'scientific' domain must now incorporate concepts from social science disciplines if they are to effectively utilize 4IR technologies and provide holistic solutions to problems in Industry 4.0.

A second trend outlined in literature on skills and the 4th industrial revolution highlights that soft skills and ethical considerations are becoming more pertinent in the era of the fourth industrial revolution and should therefore be given equal priority in developing capabilities amongst professionals and graduates to work in the 4IR space. (Anderson-Cook et al. 2019; Jones-Farmers, 2019; Sackey & Bester, 2016; Wilson et al. 2017; Coskun et al. 2019) According to Anderson-Cook et al. interdisciplinary collaboration between statisticians and subject-matter experts from other disciplines is important in the current era and must be underpinned by principles of respect, shared common goals, trust, commitment, intercommunication, and execution. (2019: 166) In their review entitled: The Jobs that Artificial Intelligence will create, Wilson et al. (2017) argue that artificial intelligence will not merely replace workers with AI and machine learning systems but rather create new jobs that are in fact human-centric. They outline 3 categories of employees that will be useful in the age of digitalisation namely, trainers: who will be required teach AI systems how to be more sympathetic and empathetic; explainers: who can "explain the inner workings of complex algorithms to nontechnical professionals" and finally the sustainers: who will play crucial role to ensure that AI systems function for their intended purpose and are not exploited. Wilson et al importantly note that "individuals in this role will act as kind of watchdog or ombudsman for the upholding of human values and morals…" (2017: 16) Thus it is evident that 4IR technologies and Industry 4.0 will not eradicate human intervention but enhance it.

As indicated in the previous section leading countries in industrial performance manufacturing, engineering and trade have implemented Industry 4.0 strategies. Coupled with these strategies are educational strategies that aim to increase collaboration among disciplines with the aim of improving on and advancing 4IR skills sets among graduates. The Turkish German University in Istanbul has established a laboratory and implemented an educational strategy that consists of three main stages of learning, i.e. curriculum, laboratory and student club. (Coskun et al. 2019) The laboratory incorporates these stages to introduce students to 4IR technologies used in Industry 4.0. For example, in the computer engineering programme at the university, the curriculum allows for three specialisation tracks in either intelligent systems, IT security or hardware systems. (Coskun et al, 2019:06) In each track relevant modules in machine learning, artificial intelligence, methods of data analysis as well as security systems, cryptology and network security are taught.

> "As the Industry 4.0 systems will mature, we will see more and more manufacturing environments that are smart and autonomous in a way that they will be able to analyze their own state and the environment and handle autonomously according to their analysis. In order to design and implement such systems, engineering students must be competent in methods of artificial intelligence and machine learning."
>
> (Coskun et al, 2019: 07)

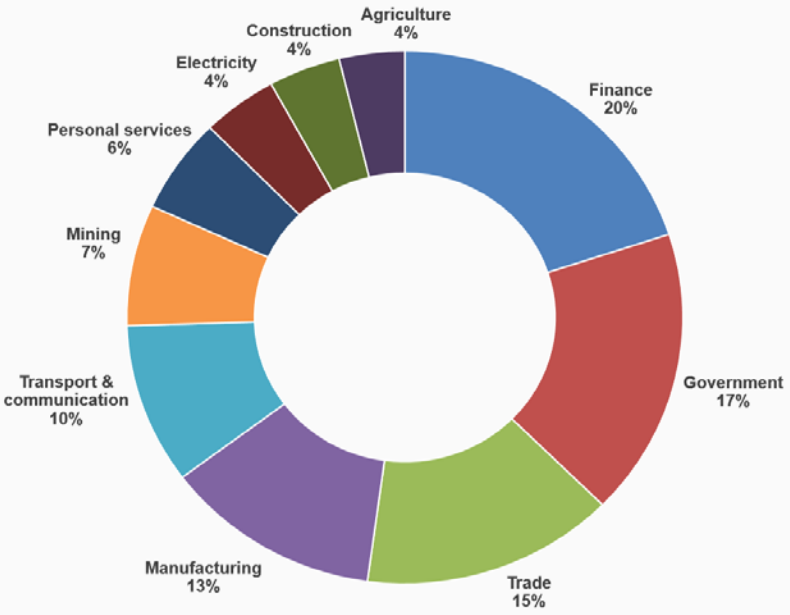
Further a visual production component has been incorporated at the lab which allow students to practice computer-aided design and manufacturing (CAD/CAM) or 3D design, both of which are relevant to the engineering discipline. Such an example of integrated learning through a lab setting at a university allows students to learn in a theoretical and experiential way. The Turkish-German University laboratory is useful to understanding how education systems can be adapted and aligned to the 4th industrial revolution.

The literature on 4IR, Industry 4.0 and skills demand indicates a multitude of new skills and capabilities are needed by individuals. The rapid pace at which 4IR transforms our industries and complexity inherent in the nature of skills required places huge demand on our educational systems. We can deduce that skills expected of 4IR by industry is multi-layered in that it requires a merging and integration of different schools of thought to enhance productivity, problem-solving and innovation. Multifunctional labs or centres of training such as the one based at the Turkish-German University demonstrates how learning can be amalgamated instead of learning difference concepts and applying these concepts in isolation. Hence it is worthwhile exploring the feasibility of applying such concepts in a South African setting. The next section reviews the South Africa context from an industry, educational and policy perspective to understand the gaps in skills and industry needs as it relates to 4IR.

3.3 The South African Context

Since the turn of the 21st century, the world economy had experience rapid expansion. And South Africa is no exception. Much of this growth in South Africa, for example, can be attributed to paradigm shift from primary sectors which were majorly agricultural, and mineral base economy to a more diversified economy (Figure 1). In particular, finance, real estate, and business (22%), wholesale and retail trade, tourism and communication (15%), and manufacturing (14%) seems to contribute the highest return of the South Africa Gross Domestic Products (GDP). The growth in these sectors are being driving by automation and technological advances.

Figure 1: Showing the main sectors contributing to the GDP of South Africa (Statistics South Africa (2017)



In recent years, however, the South Africa economy landscape is tilting towards a knowledge-based economy, with a particular focus on e-commerce, technology, finance, and other services. From an engineering industry perspective, Dr Rohde (2018) notes that "in South Africa there are indeed pockets of excellence and areas of significant innovation. Digital technology is rapidly evolving, but the industry in South Africa is not adapting fast enough. A major concern is the lack of government-mandated Building Information Modelling (BIM) standards and practices." Slow adaption to digitalisation can be attributed to a multitude of reasons including: its position in the world economy as a developing country; a lack of capital and FDI investment in some industries; and/or the lack of skills and knowledge in 4IR technologies among certain industries to inform the transition.

From examples cited in the literature it can be noted that the transition to digitalisation in advanced economies such as Germany, China, the USA and Europe have all occurred through the implementation of 4IR strategies that have guided the transformation of these countries' industries. Coupled with Industry 4.0 strategies, these countries implemented strategies for amendments to the education system to ensure that a collective restructuring of all sectors of the economy towards 4IR takes place.

It is therefore proposed that a comprehensive Industry 4.0 strategy is adopted in South Africa in order to make the transition to a 4IR economy. This must be coupled with educational reform aimed at modifying current curricula across all disciplines in order for the PSET system to align itself with the 4th industrial revolution. As

demonstrated from the literature above, educational transformation to suit the needs of a 4IR economy is not exclusive to South Africa but rather recognized as a global educational imperative. This is due to the concern that the advent of current advances in new and emerging technologies will replace traditional jobs and that the current workforce lacks the necessary skills to work in a 4IR economy.

Recognizing the growing changes in the workplace, and the widening gap between available jobs and skilled personnel, the Department of Higher Education (DHET), under the leadership of the Honorable Minister, Mrs Grace Naledi Mandisa Pandor published the National List of Occupations in Demand: 2018. The overarching goal of the list was to guarantee the ease of identification of current and future occupational demand in order to ensure that the goals of the National Development Plan, the New Growth Path, and the Industrial Policy Action Plan are achieved. The list also aims at improving the responsiveness of the Post-School Education and Training System (PSET) to the need of the economy, and the broader developmental objectives of the country (DHET, 2018).

According to DHET (2018), Occupations can be regarded as been in high demand if:

i. They have shown relatively strong employment or wage growth over the past 5 years
ii. They are expected to show relatively strong employment growth in the future
iii. Have been identified as being in shortage in the labour market
iv. Are new and are expected to emerge in the near future as a result of innovation, technological advancements, the development of new industries, or the implementation of government strategic priorities.

From the above list, it is easy to gauge that many of these features are relevant to occupations which are being impacted by relative changes and advances as a result of digitalisation such as all engineering occupations, manufacturing, banking and financial occupations, professional services, IT-related occupations, etc.

Zhong *et al.* (2017) reasoned that the fourth industrial revolution would usher intelligent manufacturing which will take advantage of advanced information and manufacturing technologies to achieve flexible, smart, and reconfigurable manufacturing processes in order to address a dynamic and global market. Noting these changes, it is sufficient to assume that a highly critical information and engineering skills would be needed to effectively leverage the new disruptors of change to address climate change. Importantly, and from South Africa context, identify the critical skills required for South Africa to align her industry in the digital era is highly paramount. Wang *et al.* (2016) revealed that the Internet of things (IoT), wireless sensor networks, big data,

cloud computing, embedded system, and mobile internet are the emerging technologies needed for a smart industries.

Concerning however, and as acknowledged by the CEO of the Council on Higher Education, Professor Narend Baijnath, vast majority of South Africans had limited access to technology and connectivity and are in reality still grappling with the third industrial revolution. Elaborating further, Professor Baijnath (2018) revealed that *"*the biggest obstacle we have is the cost of bandwidth and connectivity were vast numbers of students don't have sufficient access and affordable connectivity. According to the CEO, the real challenge for universities was that the current model for producing students of higher education had not changed in hundreds of years, and the model was no longer resonant with the fourth industrial revolution. He stated that *"In reality we will be losing jobs through automation; populations are growing; there is less need for skilled people and more need for skills that our graduates do not have and are difficult to produce. So universities have to rethink their activities."*

As a way forward, Professor Baijnath (2018) called for curriculum reform in the higher education institution. According to his view, "*higher educationists had a challenge to explore, on an ongoing basis, what the implications of the fourth industrial revolution were for curriculum reform and the kinds of graduates produced".* What is iterated by academics, practitioners and politicians about the South African PSET curriculum is that it needs to keep abreast of changes and update its curriculum accordingly. However this cannot be done in isolation. The preliminary recommendations proposed in this report are to:

A. As a top-down approach- government should firstly implement a 4IR strategy
B. Review and update school curricula as a starting point in trying to align the PSET system to 4IR and Industry 4.0. This promotes a bottom-up approach as the students entering the PSET system are inevitably products of our school system.
C. Encourage and embrace industry involvement in re-designing PSET curricula in order to bridge the gap between industry needs and the kind of graduates produced.

Conclusion

A desktop survey of university and university of technology (UoT) degree and diploma programmes offered reveal that South Africa has made attempts to diversify the PSET curricula with a few university courses in Data Science and specialisation streams in courses like artificial intelligence. This study asserts that such courses alone are not sufficient for preparing graduates for the 4th industrial revolution. Hence the preliminary recommendations above are proposed. As seen in the cases of China and Germany, Industry 4.0 strategies can

direct and guides the transition to Industry 4.0 across all industries including the education sectors. As such, an Industry 4.0 strategy in South Africa will be useful.

With reference to the second recommendation, Minister of Basic Education, Angie Motshekga published a Ministerial statement relating to 4IR and basic education in which she noted that the Brookings Institute found that the South African school curriculum has embedded in it the competencies required for a changing world. These include critical thinking and problem-solving, creativity and innovation, collaboration and teamwork, communication and information literacy, as well as social justice and human rights. Apparently our school curriculum has the potential to foreground 21st-century skills. (Gravett, 2019) As a result, the school system is worth reviewing to undertake an update of both school and PSET curricula.

A demonstrated in the literature review, industry is leading in new and emerging technologies. Academics often teach standardised curricula and industry is far ahead of this method with practical experience and current knowledge of world trends. Welsh notes that in age of the 4th industrial revolution, technical and vocational schools have become the trend because people recognize the outdated nature of curricula in universities and schools globally. These schools and college are often founded through partnerships between leading companies such as Volkswagen and government. South Africa needs to look towards such solutions as well in bridging the gap between industry and universities.

A more comprehensive analysis of the South African university curriculum will be undertaken once primary data collection is undertaken from Universities, Universities of Technology and TVET Colleges. From the literature survey conducted, the researchers of this report have also established that industry experts in South Africa also need to be consulted through the hosting of insight workshops in order to ascertain the gap between skills and industry needs.

Bibliography:

Agarwal, R. and Weill, P. 2012. The benefits of combining data with empathy. *MIT Sloan Management Review* (Blog). Available: http://sloanreview.mit.edu/article/the-benefits-of-combining-data-with-empathy/. (Accessed June 13, 2019).

Annonymous (2018)"The Fourth Industrial Revolution - an opportunity to reposition", 2018, *Civil Engineering : Magazine of the South African Institution of Civil Engineering,* vol. 26, no. 10, pp. 8-9. Available in: https://search.proquest.com/docview/2169565417/fulltextPDF/9278295801B14B39PQ/1?accountid=10612

Barton, D. and Court, D. 2012. Making advanced analytics work for you. *Harvard Business Review*, 78 (10): 83.

Buyya, R., Yeo, C. S., Venugopal, S., Broberg, J. and Brandic, I. 2009. Cloud computing and emerging IT platforms: Vision, hype, and reality for delivering computing as the 5th utility. *Future Gener Comp Sy*, 25 (6): 599-616.

Caffrey, T. and Wohlers, T. 2015. *Additive Manufacturing and 3 D Printing State of the Industry- Annual Worldwide Progress Report,* . Available: https://wohlersassociates.com/2015-ExSum.pdf (Accessed June 18, 2019).

Chauke, A. (2018) Jobs and skills in the Fourth Industrial Revolution, South African Government News Agency, 18 December 2018. Available in: https://www.sanews.gov.za/features-south-africa/jobs-and-skills-fourth-industrial-revolution

Chen, M., Mao, S. and Y. Liu, Y. 2014. Big data: a survey. *Mobile Networks and Applications,*, 19 (2): 171-209.

Chen, Y. H., Ho, P. H. and Chiu, M. C. 2017. Utilising Cyber Physical System to achieve intelligent product design: A case study of transformer. In: Chen, C. H., Trappey, A. C. and Peruzzini, M. eds. *Transdisciplinary Engineering: A Paradigm Shift: Proceedings of the 24th ISPE Inc. International Conference on Transdisciplinary Engineering*. IOS Press.

Choonara, Y. E., du Toit, L. C., Kumar, P., Kondiah, P. P. and Pillay, V. 2016. 3D-printing and the effect on medical costs: a new era? *Expert review of pharmacoeconomics & outcomes research*, 16 (1): 23-32.

Coşkun, S., Kayıkcı, Y. and Gençay, E., 2019. Adapting Engineering Education to Industry 4.0 Vision. *Technologies*, *7*(1), p.10. Available in: https://www.mdpi.com/2227-7080/7/1/10

DHET, 2018. National List of Occupations in High Demand. *Government Gazette,* 636 (42728): 1-24. Available: www.dhet.gov.za/Information%20Systems%20Coordination/GAZETTE.pdf (Accessed 24 May 2019).

Dhell, S (2018) Using 4IR technology for the greater good, *University World News: Africa Edition*, 05 October 2018.

Available in: https://www.universityworldnews.com/post.php?story=20181003143515944

Digital pneumatics. 2017. *The first valve to be controlled using apps [Internet]. Esslingen: Festo AG & Co. KG* (online). Available: https://www.festo.com/vtem/en/cms/10169.htm (Accessed June 18, 2019).

Dodziuk, H. 2016. Applications of 3D printing in healthcare. *Kardiochirurgia i torakochirurgia polska= Polish journal of cardio-thoracic surgery*, 13 (3): 283.

European Commission. 2017. *Digital Transformation Monitor Germany: Industrie 4.0*.

Evans, P. C. and Annunziata, M. 2012. *Industrial Internet: Pushing the boundaries of minds and machines* Boston: General Electric Company.

Fedak, V. 2018. 8 Open Source Big Data Tools to use in 2018. *Towards Data Science* (Blog).

Gil, D., Johnsson, M., Mora, H. and Szymanski, J. 2019. Advances in Architectures, Big Data, and Machine Learning Techniques for Complex Internet of Things Systems. *Complexity*, 2019

Guerrieri, A., Loscri, V., Rovella, A. and Fortino, G. 2016. *Management of cyber physical objects in the future internet of things*. Springer.

Gravett, S (2019) Industry 4.0 is being taken seriously, Mail and Guardian, 18 January 2018. Available in: https://mg.co.za/article/2019-01-18-00-industry-40-is-being-taken-seriously

Hashem, I. A. T., Yaqoob, I., Anuar, N. B., Mokhtar, S., Gani, A. and Khan, S. U. 2015. The rise of "big data" on cloud computing: Review and open research issues. *Information systems*, 47: 98-115.

Horizon 2020. 2017. *The EU framework programme for research and innovation.* . Brussels:: European Commission. Available:

https://ec.europa.eu/programmes/horizon2020/ (Accessed June 21, 2019).

Industrial Internet consortium. 2017. *Iiconsortium.org* Needham; USA: Object Management Group, Inc. Available: http://www.iiconsortium.org/ (Accessed June 21, 2019).

Kagermann, H., Wahlster, W. and Helbig, J. 2013. *National Academy of Science and Engineering. Recommendations for implementing the strategic initiative INDUSTRIE 4.0: Final report of the Industrie 4.0 Working Group*. Munich: National Academy of Science and Engineering.

King, B.A., Hammond, T. and Harrington, J., 2017. Disruptive Technology: Economic Consequences of Artificial Intelligence and the Robotics Revolution. *Journal of Strategic Innovation and Sustainability*, *12*(2), pp.53-67.

Available in: https://search.proquest.com/openview/bddca98164340c9fb8054ddd9ea262ba/1?pq-origsite=gscholar&cbl=536313

Jones-Farmer, L.A., 2019. Leveraging industrial statistics in the data revolution: The Youden Memorial Address at the 63rd Annual Fall Technical Conference. *Quality Engineering*, *31*(2), pp.205-211. Available in: https://www.tandfonline.com/doi/full/10.1080/08982112.2019.1572187

Laszczak, P., Jiang, L., Bader, D. L., Moser, D. and Zahedi, S. 2015. Development and validation of a 3D-printed interfacial stress sensor for prosthetic applications. *Medical engineering & physics*, 37 (1): 132-137.

Lee, J., Kao, H.-A. and Yang, S. 2014. Service innovation and smart analytics for industry 4.0 and big data environment. *Procedia Cirp*, 16: 3-8.

Lee, J., Wu, F., Zhao, W., Ghaffari, M., Liao, L. and Siegel, D. 2014. Prognostics and health management design for rotary machinery systems—Reviews, methodology and applications. *Mech Syst Signal Process*, 1-2 (42): 314-334.

Li, L. 2018. China's manufacturing locus in 2025: With a comparison of "Made-in-China 2025" and "Industry 4.0". *Technological Forecasting and Social Change*, 135: 66-74.

Liu, Q., Wan, J. and Zhou, K. 2014. Cloud manufacturing service system for industrial-cluster-oriented application. *Journal of Internet Technology*, 15 (4)

Long, Y., Pan, J., Zhang, Q. and Hao, Y. 2017. 3D printing technology and its impact on Chinese manufacturing. *International Journal of Production Research*, 55 (5): 1488-1497.

Manyika, J., Chui, M., Brown, B., Bughin, J., Dobbs, R. and Roxburgh, C. 2011. *Big data: The next frontier for innovation, competition, and productivity*. New York: McKinsey Global Institute.

Mendoza, H. R. 2015. *Surgeons Create 3D Printed Custom Implant to Restore Pelvis after Resection* (online). Available: https://3dprint.com/91580/3d-printed-pelvic-implant/ (Accessed June 18, 2019).

Mzekandaba, S (2019) SA universities must lead Industry 4.0 curriculum, IT Web, 22 March 2019 Available in: https://www.itweb.co.za/content/PmxVE7KXLopMQY85

Morrison, R. J., Hollister, S. J., Niedner, M. F., Mahani, M. G., Park, A. H., Mehta, D. K., Ohye, R. G. and Green, G. E. 2015. Mitigation of tracheobronchomalacia with 3D-printed personalized medical devices in pediatric patients. *Science translational medicine*, 7 (285): 285ra264-285ra264.

Negi, S., Dhiman, S. and Kumar Sharma, R. 2014. Basics and applications of rapid prototyping medical models. *Rapid Prototyping Journal*, 20 (3): 256-267.

Pillay, N., Maharaj, B.T. and van Eeden, G., 2018, November. AI in Engineering and Computer Science Education in Preparation for the 4th Industrial Revolution: A South African Perspective. In *2018 World Engineering Education Forum-Global Engineering Deans Council (WEEF-GEDC)* (pp. 1-5). IEEE. Available in: https://ieeexplore.ieee.org/abstract/document/8629703/

Posada, J., Toro, C., Barandiaran, I., Oyarzun, D., Stricker, D., de Amicis, R., Pinto, E. B., Eisert, P., Döllner, J. and Vallarino, I. 2015. Visual computing as a key enabling technology for Industrie 4.0 and industrial internet. *IEEE computer graphics and applications*, 35 (2): 26-40.

Prisecaru, P., 2016. Challenges of the fourth industrial revolution. *Knowledge Horizons. Economics*, *8*(1), p.57. Available in: http://orizonturi.ucdc.ro/arhiva/khe-vol8-nr1-2016/09.%20Petre%20Prisecaru.pdf

Qiu, M. and Sha, E. 2007. *"Energy-aware online algorithm to satisfy sampling rates with guaranteed probability for sensor applications," in High Performance Computing and Communications,*. Berlin, Germany: Springer.

Rich, S. 2012. *Big data is a "new natural resource," IBM says* (online). Available: http://www.govtech.com/policy-management/Big-Data-Is-a-New-Natural-Resource-IBM-Says.html. (Accessed June 13, 2019).

Sackey, S.M. and Bester, A., 2016. Industrial engineering curriculum in Industry 4.0 in a South African context. *South African Journal of Industrial Engineering*, *27*(4), pp.101-114. Available in: http://www.scielo.org.za/scielo.php?pid=S2224-78902016000400009&script=sci_abstract&tlng=af

Saxena, V. K. and Pushkar, S. C. 2016. loud computing challenges and implementations. In: Proceedings of *Proceedings of 2016 International Conference on Electrical, Electronics, and Optimization Techniques*. Chennai, India. Piscataway, The Institute of Electrical and Electronics Engineers, Inc, 2583-1288.

Schess, N. 2013. Then and Now: How Technology has changed the Workplace. *Hofstra Labor and Employment Law Journal,* 30(2): 435-457.

Soliman, F. and Youssef, M. A. 2003. Internet-based e-commerce and its impact on manufacturing and business operations. *Industrial Management & Data Systems*, 8-9 (103): 546-552.

Tao, F., Zuo, Y., Xu, L. D. and Zhang, L. 2014. IoT-Based intelligent perception and access of manufacturing resource toward cloud manufacturing,. *IEEE Transactions on Industrial Informatics,*, 10 (2): 1547-1557.

Waibel, M., Steenkamp, L., Moloko, N. and Oosthuizen, G. 2017. Investigating the effects of smart production systems on sustainability elements. *Procedia Manufacturing*, 8: 731-737.

Wan, J., Li, D., Yan, H. and Zhang, P. 2010. Fuzzy feedback scheduling algorithm based on central processing unit utilization for a software-based computer numerical control system. *Proceedings of the Institution ofMechanical Engineers, Part B: Journal of Engineering Manufacture*, 224 (7): 1133-1143.

Wang, S., Wan, J., Li, D. and Zhang, C. 2016. Implementing smart factory of Industrie 4.0: an outlook. *International Journal of Distributed Sensor Networks*, 12 (1): 3159805.

Welsh, B.L (2018) Education 4.0: How we will learn in fourth industrial revolution, Online Blog. Available in: https://medium.com/@brianna_91610/education-4-0-how-we-will-learn-in-the-fourth-industrial-revolution-e17206b73016

Wilson, H.J., Daugherty, P. and Bianzino, N., 2017. The jobs that artificial intelligence will create. *MIT Sloan Management Review*, *58*(4), p.14.

Avaible in: http://ilp.mit.edu/media/news_articles/smr/2017/58416.pdf

World Economic Forum. 2019. *The 7 technologies changing your world* (online). Available: https://www.weforum.org/agenda/2016/01/a-brief-guide-to-the-technologies-changing-world/ (Accessed

World Economic Forum (2018) Future of Jobs Report, Centre for the New Economy and Society, pp. 1-147. Available in: http://www3.weforum.org/docs/WEF_Future_of_Jobs_2018.pdf

Xia, F., Yang, L. T., Wang, L. and Vinel, A. 2012. Internet of things. *International Journal of Communication Systems*, 25 (9): 1101.

Xu, G., Wu, Y., Minshall, T. and Zhou, Y. 2018. Exploring innovation ecosystems across science, technology, and business: A case of 3D printing in China. *Technological Forecasting and Social Change*, 136: 208-221.

Xu, X. 2012. From cloud computing to cloud manufacturing. *Robot Com-Int Manuf*, 28 (1): 75-86.

Zhang, Q., Cheng, L. and Boutaba, R. 2010. Cloud computing: State-of-the-art and research challenges. *J Int Serv Appl*, 1 (1): 7-18.

Zhong, R. Y., Xu, X., Klotz, E. and Newman, S. T. 2017. Intelligent manufacturing in the context of industry 4.0: a review. *Engineering*, 3 (5): 616-630.