Article

Industry 4.0 in Finance: The Impact of Artificial Intelligence (AI) on Digital Financial Inclusion

David Mhlanga

School of Accounting, University of Johannesburg, Johannesburg 2006, South Africa; dmhlanga67@gmail.com

check for updates

Abstract: This study sought to investigate the impact of AI on digital financial inclusion. Digital financial inclusion is becoming central in the debate on how to ensure that people who are at the lower levels of the pyramid become financially active. Fintech companies are using AI and its various applications to ensure that the goal of digital financial inclusion is realized that is to ensure that low-income earners, the poor, women, youths, small businesses participate in the mainstream financial market. This study used conceptual and documentary analysis of peer-reviewed journals, reports and other authoritative documents on AI and digital financial inclusion to assess the impact of AI on digital financial inclusion. The present study discovered that AI has a strong influence on digital financial inclusion in areas related to risk detection, measurement and management, addressing the problem of information asymmetry, availing customer support and helpdesk through chatbots and fraud detection and cybersecurity. Therefore, it is recommended that financial institutions and non-financial institutions and governments across the world adopt and scale up the use of AI tools and applications as they present benefits in the quest to ensure that the vulnerable groups of people who are not financially active do participate in the formal financial market with minimum challenges and maximum benefits.

Keywords: artificial intelligence; digital financial inclusion; finance; industry 4.0

JEL Classification: G2; G4; O; O16

1. Introduction

Digital financial inclusion is increasingly becoming central in the debate on how to ensure that people who are at the lower levels of the pyramid become financially active (Peric 2015). Banks and non-bank institutions are coming together to widen financial access using digital financial approaches to include those who are financially excluded and the underserved populations (Peric 2015). Banks and non-banking institutions are building on digital ways that were in use for years through the direct application of artificial intelligence (AI) to improve access even to the people who were previously served by the formal financial institutions (Alameda 2020; Peric 2015). The fourth industrial revolution is bringing changes in the traditional banking sector built in the industrial revolution premised on paper and physical distribution of cash (Alameda 2020).

The term fintech or financial technologies is used to describe different innovative business models that have great potential to transform the financial services industry (Mamoshina et al. 2018). The fintech business model offers various financial products or services in an automated fashion through the wide use of the internet (Paul 2019). Technologies that are driving industry 4.0 such as AI, machine learning, cognitive computing and distributed ledger technologies can be used to supplement fintech new entrants and traditional incumbents (Lopes and Pereira 2019a). Some other AI technologies that can be applied in the fintech sector to promote financial inclusion including *audio processing, knowledge representation, speech to text, deep learning, expert systems, natural language processing, machine learning*

(ML), robotics, and symbolic logic (Paul 2019). It is believed that the popularity of AI technologies boomed in 2011 when companies like Google, Microsoft, IBM and Facebook embarked on a massive investment in AI and machine learning to be applied in the commercial space.

The traditional banking market is equipped with millions of customers with a history that spans over hundreds of years, and some of these customers may be worth billions (Alameda 2020; Peric 2015). The challenge which is currently there is that these customers are not digital (Alameda 2020; Loufield et al. 2018). On the other hand, fintech start-ups have a rich digital vision but to win the trust of customers is a huge obstacle to them (The World Bank 2020). The occurence of the disturbances caused by COVID-19 brought another perspective of fintech to customers as it was the only option available to engage in banking as well as buying. Banks resorted to digital banking while shopping in many countries was done online using various banking applications to perform transactions. In addition, the existence of various tech corporations like Google, Apple, Facebook Amazon in America and Baidu, Alibaba and Tencent in Asia who take pride in having millions of customers with financial returns in the billions and decades of history and a pure digital vision will act as examples a for banks to embrace digital technology and to understand the importance of AI in finance (Alameda 2020).

The World Bank stated that digital financial services which include the use of mobile phones have been launched in more than 80 countries (The World Bank 2020; Chu 2018). As a result, millions of formerly excluded and underserved poor individuals are migrating from cash-based transactions to formal financial services where a variety of services like payments, transfers, credit, insurance, securities and savings are offered to them (The World Bank 2020). Mobile phones and other digital tools including AI are widely used and the rate at which financial inclusion is rising is commendable (Salampasis and Mention 2018; Bill & Melinda Gates Foundation 2019). With digital financial inclusion, financial services are provided to customers at an affordable cost in ways that are sustainable to customers (Gomber et al. 2017). Digital financial services provide unlimited benefits to the previously excluded customers but it comes with a lot of risks which result from the introduction of non-financial firms in the provision of new technologies used in the process (The World Bank 2020; Rathi 2016).

Another risk in digital finance lies in the existence of new contractual relationships between financial institutions and third parties which involve the use of agent networks, other risks result from different regulatory treatment of deposit-like products as compared to real deposits, there are other risks which result from unknown and unpredictable costs to inexperienced and vulnerable consumers, together with risks that result from the use of new kinds of data which come with new privacy and data security issues (The World Bank 2020; Rathi 2016). However, experts are indicating that the use of AI (particularly algorithms) can help to fight some of the risks (Chu 2018; Killeen and Chan 2018). Motivated by the fact that in the industry 4.0, AI is increasingly becoming common while on the other hand digital financial inclusion is becoming central in the debate on how to ensure that people who are at the lower levels of the pyramid become financially active, for instance, groups of women, youths, small businesses among many disadvantaged groups. This study, therefore, intends to investigate the impact of AI on digital financial inclusion, that is to understand the channels in which AI can help to improve financial inclusion.

1.1. History and Definition of Digital Financial Inclusion

Financial inclusion refers to the number of adults having access to banking or financial services. The Global Findex Survey reported that in the 15+ age group, 79.9% of the population had accounts with financial institutions in the year 2017 (Demirguc-Kunt et al. 2017). This meant a strong growth compared to 53.1% reported in the previous edition of the survey in 2014, and 35.2% in 2011. Nearly half of the world's adult population (or 3.5 billion people) are unbanked and underbanked (with limited or non-transactional access to finance). Of these 1.7 billion adults in the world without an account, China, India, Pakistan and Indonesia account for the largest unbanked persons.

The first step towards financial inclusion is having an account (Sarma 2015). Increasingly, digital payments are being used for financial transactions (Muneeza et al. 2018). Digital financial

inclusion is explained by the World bank as the deployment of cost-saving digital means to reach the financially excluded and the generally underserved population groups with formal financial services that are tailor-made to satisfy their needs (Alameda 2020). Wang and He (Wang and He 2020) also described digital financial inclusion as broad access to and use of formal financial services by the excluded or underserved individual. Digital financial inclusion began to attract the attention of many people as a result of the success of M-PESA, one of the payment innovations introduced in Kenya (Beck et al. 2018). With M-PESA, mobile money is used for digital payments (Dubus and Van Hove 2017; Van Hove and Dubus 2019). According to Wang and He (Wang and He 2020), digital financial inclusion in China represents more than a payment instrument as it includes three basic business formats which include digital payments, digital investment and digital financing.

Digital financial inclusion put more emphasis on the importance of information communication technology (ICT) in expanding the scale as well as the use of financial services by the previously disadvantaged individuals (Lauer and Lyman 2015; Wang and He 2020). The journey started with microcredit, microfinance and financial inclusion, then the journey is now striving for digital financial inclusion (Lauer and Lyman 2015). The word microcredit was first used to refer to institutions like the Grameen Bank of Bangladesh which was created to provide small loans to the poor (Chatterjee and Sarangi 2006; Wang and He 2020). In the early 1990s, the word microcredit was dominating before it was replaced by the word microfinance which was described as the supply of a variety of financial services which include savings, insurance, loans (Karlan and Morduch 2010; Wang and He 2020).

The field-based operation which was used by banks like Grameen where microcredit, microfinance and financial inclusion was developed, weakened the efficiency of these banks in serving the poor (Visser and Prahalad 2013). The existence of ICT and AI made it possible for financial inclusion to change to digital financial inclusion which is the fourth stage which will change the lives of those individuals at the bottom of the pyramid (Visser and Prahalad 2013). Wang and He (Wang and He 2020) indicated that to do business with people at the bottom of the pyramid requires unique business models and radical innovations such as AI. Wang and He (Wang and He 2020) noted that digital financial inclusion is different from traditional financial inclusion because digital financial services reduce transaction costs in rural areas due to lower marginal costs. When relying on ICT digital financial services require no physical outlets. However, coming up with new technologies face higher start-up costs to have them established, but their marginal costs normally move towards zero when business volume increases (Liao et al. 2020).

The use of AI and various ICT tools helps to overcome the major problem of traditional financial inclusion which is information asymmetry (Gomber et al. 2017). Online services and products offer a lot of information to customers which could not be accessible without the use of digital services. The availability of this information helps to reduce information asymmetry between the financial institutions and individuals (Gomber et al. 2017).

The important components of digital financial inclusion include but are not limited to digital transaction platforms, which allow customers to make payments and to store electronic value (Peric 2015; GPFI 2017). The other important aspect provided by digital finance is devices which are used by customers which can either be digital devices like mobile phones that can transmit information or instruments like payment cards that can be used to connect with digital devices like point of sale terminals (Alameda 2020; Bill & Melinda Gates Foundation 2019). Moreover, digital financial inclusion is characterized by retail agents with digital devices connected to communication infrastructure that will transmit and receive transaction details. This activity allows customers to convert cash into electronically stored value also referred to as cash in or to convert back the stored values back into cash which can also be referred to as cash-out (Peric 2015). With digital financial inclusion, additional financial services like credit, insurance and even savings can be offered by banks and non-banks to the financially excluded and those underserved individuals through digital tools like AI.

As articulated by Peric (2015) the benefits of digital financial inclusion include access to formal financial services by the financially excluded individuals, and the fact that digital financial services

and products are offered at a lower cost to the customer and the provider. This allows customers to transact in irregular tiny amounts to assist them to manage their uneven incomes (Koh et al. 2018). Additionally, with digital financial inclusion, it is possible to have additional financial services tailor-made for customers' needs and financial circumstances which are made possible by the value storage services embedded in it and the data generated within it (Bourreau and Valletti 2015). Digital financial services also help to reduce risks of loss, theft, and other financial crimes posed by cash-based transactions, as well as the reduced costs associated with transacting in cash and using informal providers (Muneeza et al. 2018). Again, it can also promote economic empowerment by enabling asset accumulation for women, in particular, increasing their economic participation (David-West 2015; Peric 2015).

1.2. Industry 4.0

Industry 4.0, also known as the fourth industrial revolution, can be described as the advent of cyber-physical systems involving entirely new capabilities for people and machines (Schwab 2015). While these capabilities are reliant on the technologies and infrastructure of the third industrial revolution, the 4IR represents entirely new ways in which technology becomes embedded within societies and even our human bodies (Schwab 2015). 4IR is defined as the fusion of technologies that is blurring the lines between the physical, digital, and biological worlds (Schwab 2015; Moloi 2020). The term 4IR was first coined by Klaus Schwab, founder and executive chairman of the World Economic Forum. *"The 4IR is sometimes described as an incoming thunderstorm, a sweeping pattern of change visible in the distance, arriving at a pace that affords little time to prepare. While some people are ready to face the challenge, equipped with the tools to brave the change and take advantage of its effects, others do not even know a storm is brewing"* (Deloitte 2018a).

The 4IR is affecting almost every facet of our daily life, impacting how individuals relate to technology and changing how and where work is done (Schwab 2019). Another way to have an understanding of industry 4.0 is to appreciate the technology used in this revolution. Some of the technologies include artificial intelligence and robotics, ubiquitous linked sensors, virtual and augmented realities, additive manufacturing, blockchain and distributed ledger technology, advanced materials and nanomaterials, energy capture, storage and transmission, new computing technologies, biotechnologies, geoengineering, neurotechnology, space technologies. These are some of them that are driving the fourth industrial revolution in the 21st century (Schwab 2019; Moloi 2020).

1.3. Brief Definition and History of Artificial Intelligence

As propounded by Hassani et al. (2020), artificial intelligence has multiple definitions. As a result, no one definition can define artificial intelligence (Hassani et al. 2020). Legg and Hutter (2007) came up with 70 definitions of artificial intelligence covering multiple views. Colom et al. (2010) defined artificial intelligence as a general mental ability for reasoning, problem-solving, and learning while Snyderman and Rothman (1987) defined artificial intelligence as a general mental ability for reasoning, problem-solving, and learning. Gottfredson (1997) also defined artificial intelligence where more emphasis was given to learning swiftly and the ability to learn from experiences. Hassani et al. (2020) also defined AI as an intelligent system created to use data and to analyze the data as well as involving the performance of certain tasks without the need for programming. AI has a strong capacity to create a foundation for decision making and support through insights and results, collected from vast and complex data sets which are compressed into the manageable scale (Hassani et al. 2020).

There were generations of scientists, mathematicians and philosophers who had the concept of AI in their minds by the 1950s (An Editorial with 52 Researchers 1994). Gottfredson (1997) insinuated that the history of AI began in the periods of human classical civilization with myths and rumours of artificial beings endowed with intelligence or consciousness by master craftsmen. The attempt by the classical philosophers to describe the process of human thinking as the mechanical manipulation of symbols gave more meaning to the concept of AI (Colom et al. 2010). As articulated by Colom et al. (2010),

the effort in describing human thinking as mechanical manipulation culminated in the invention of programmable digital computers in the 1940s. These programmable computers were machines premised on the abstract essence of mathematical reasoning (Hassani et al. 2020). The ideas around the developed device influenced several scientists to start discussing, with seriousness, the possibility of coming up with an electronic brain (Gottfredson 1997).

According to Hassani et al. (2020), artificial intelligence was mentioned for the first time in 1956 at a computing conference. In 1956 in a workshop at Dartmouth College during the summer of 1956, the research on AI began. The people who attended the workshop became the leaders of AI for decades (Hassani et al. 2020). Considerable investment in AI boomed in the first decades of the 21st century due to availability of large data sets, powerful computer hardware and due to the availability of new methods. This motivated the application of machine learning to many problems in academia and industry (Frank 2019; Hassani et al. 2020). In this century AI has evolved from being an academic field to become a key factor in the social and economic mainstream technologies including banking, medical diagnosis, autonomous vehicles as well as voice-activated assistance (Frank 2019).

1.4. Literature Review

The literature on digital financial inclusion is available, especially literature on how mobile phones are increasingly influencing financial inclusion. Ozili (2018) insinuated that digital financial inclusion is a critical component of the efforts applied in trying to include the groups of people who are not part of the formal financial system. Ozili (2018) went on to argue that digital finance is beneficial to financial users, providers governments and the general economy. However, Ozili (2018) believes that there are many issues which still need to be resolved in digital finance, about regulation among others.

Additionally, Dawei et al. (2018) also argued that it is a paradox in a globalized world to have a third of the population who are not part of the formal financial system, yet literature points out that financial services can assist to improve the welfare of the households and to promote small businesses. Dawei et al. (2018) believes that the inherent limitations of the conventional financial system hinder the prospects of the excluded population. However, Dawei et al. (2018) believes that digital financial inclusion through digital currency and mobile technology can help penetration of financial systems in the unserved parts of the world or country. It is believed that the high cost for small-ticket financial transactions makes these services virtually impossible and unavailable (Dawei et al. 2018).

Dawei et al. (2018) went further to state that digital currency and mobile technology allow small transactions at an affordable cost which is a benefit to small businesses and vulnerable groups. Digital currency and mobile transactions can also help to reduce time and to make transactions in bulk and with accuracy (Dawei et al. 2018). Many developing nations such as Brazil, India, Nigeria and other African nations like Kenya and Zimbabwe embraced mobile technology to overcome the problem of financial exclusion.

Sapovadia (2018) also argued that digital financial inclusion is different from traditional banking in that it serves the clients without requiring historical records. Sapovadia (2018) went further to state that digital financial inclusion uses data technology and AI to unravel credit assets of clients and mitigate information asymmetry. It is believed that the availability of AI and big data allow the use of alternative information like shopping history, online behavior pattern, transaction record and many other potential information sources of information not common to the convectional banking for credit scoring. Credit Ease Financial Cloud is one of the examples of big data which provides open and always accessible functions of anti-fraud, risk management, real-time loan granting and targeted marketing to external and internal people.

In addition, Levin et al. (2018) also argued that the crisis of the 1960s created the need for the growth and development of electronic trading and the development of financial services technology. The author believes that technology like AI is important in the financial sector as people are preparing for the new era. Hotchkiss and Lee Kuo Chuen (2018) support Levin et al. (2018), Hotchkiss and Lee Kuo Chuen (2018) argued that the development of innovations like fintech and blockchain technology

has taken the attention off the people around the world and the attention of the banking world. Hotchkiss and Lee Kuo Chuen (2018) stated that digital financial inclusion is doing great things in Myanmar, one of the fastest-growing economies in Southeast Asia where approximately 52 million people who live in the country are gaining access through digital financial inclusion.

Killeen and Chan (2018) also stated that bitcoin blockchain is creating new ways of transacting with security without the need for an intermediary. Killeen and Chan (2018) went on to insinuate that the use of ledger to verify and record identity and asset ownership for individuals to have access to the transactional account is free from the limitation associated with centralized controls when blockchain is used. Killeen and Chan (2018) believe that blockchain is satisfying the old needs previously served by convectional banks more efficiently which risks rendering the existence of the old central institutions like development banks and large scale investment firms obsolete. Killeen and Chan (2018) further argued that global financial institutions must try to respond swiftly to the changes in culture and dynamic values accompanied by blockchain innovation.

David-West (2015) also believes that digital financial inclusion can help many households who were previously excluded to have access to formal financial services. David-West (2015) believes that documentation requirements, costs and literacy issues are some of the factors forcing households and individuals to adopt informal financial services. The existence of mobile money and digital currency has revolutionized the traditional perspective of financial access and inclusion. Moreover, digital financial currency and mobile money have led to the introduction of new financial service providers such as mobile money operators sometimes referred to as agents in many African countries such as Kenya and Zimbabwe. The existence of mobile money also resulted in policy changes that led to the existence of other operators which led to the unbanked community being offered financial services (David-West 2015).

Rathi (2016) also stated that digitization has enabled a large population of individuals who were not financially active to be able to enjoy financial services due to the fact that digital tools make the financial services affordable to many. Rathi (2016) also reiterated that developing nations such as India are relying on digital technology to provide financial services to the unbanked population. In a way, digital technology is allowing the previously unbanked population to be included in the mainstream formal financial market. Chu (2018) also argued that digital technology is expanding financial inclusion where it is made possible for the unbanked to be able to access banking services like savings, insurance, and other financial services crucial to the unbanked population and those living in poverty. Chu (2018) argued that financial inclusion is important to bridge the gap between the physical, digital and the psychological use of money. Chu (2018) also believes that bringing together the digital financial tools such as blockchain with the psychological tools like financial education can allow the unbanked to have access to financial services which can help to break the poverty cycle.

Salampasis and Mention (2018) in the paper, *fintech: harnessing innovation for financial inclusion*, argued that financial inclusion has been taken as the soft side of financial services with limited attention given to it from the regulators, and policymakers despite its importance in the empowerment of the marginalized population. Salampasis and Mention (2018) argued that many disadvantaged people in society are left out of the formal financial market, thus creating inequality and general dependence syndrome by those who are unable to access financial services and making the fight against poverty difficult. However, Salampasis and Mention (2018) also suggested that the emergence of fin-tech, a new breed of financial innovation, is increasingly closing the gap between unbanked, underbanked and developed societies. Salampasis and Mention (2018) believe that digital technology is opening previously closed doors in the digital economy for many individuals leading to more equitable growth and society.

Muneeza et al. (2018), in the paper, *the application of blockchain technology in crowdfunding: towards financial inclusion* via *technology*, posit that the advent of innovative digital technologies such as blockchain and crowdfunding is showing new sustainable ways to support the economically poor and the vulnerable people. Muneeza et al. (2018), after an investigation of the development of

crowdfunding in Malaysia, found out that crowdfunding is a necessary way to promote financial inclusion while blockchain can assist in mitigating the risks faced by platform operators.

In summary, the empirical literature review discovered that literature on digital financial inclusion is available, especially literature on how mobile phone technologies are influencing financial inclusion. In this review, it was noted that digitization has enabled a large population of individuals who were not financially active to be able to enjoy financial services because digital tools make the financial services affordable to many. The review also discovered that digital technology is expanding financial inclusion where it is made possible for the unbanked to be able to access banking services like savings, insurance, and other financial services crucial to the unbanked population and those living in poverty. The other important aspect noted was that financial inclusion is important to bridge the gap between the physical, digital and the psychological use of money. Authors like Arifin (Muneeza et al. 2018) indicate that the emergence of innovative digital technologies such as blockchain and crowdfunding is showing new sustainable ways to support the poor.

1.5. Research Methodology

This study article is premised on desktop research to investigate the impact of AI on digital financial inclusion. The study used unobtrusive research techniques to analyze objectively the impact of AI on digital financial inclusion. The techniques include conceptual and documentary analysis of peer-reviewed journals, reports and other authoritative documents on AI and digital financial inclusion.

Table 1 gives an estimated number of journal articles, reports and other authoritative documents which include news articles and web page articles that helped to shape the direction of the study. Some of the journal reports and news articles listed were not necessarily referenced in the paper as they contributed to ideas which led to the development of the paper. The criteria used in the selection of the articles, reports and other important documents were simply the relevance of the articles in the provision of information useful for the main objective of the study which was to investigate the impact of AI on digital financial inclusion. Conceptual analysis and document analysis were used in the study because documents come in a variety of forms, making documents a very accessible and reliable source of data. Obtaining and analysing documents is often far more cost-efficient and time-efficient compared to conducting field research or experiments.

Table 1. Journal articles, reports and news articles that shaped the trajectory of the study.

Journal Articles	Reports	Other Documents Web Pages Articles and News Articles
66	33	40

Source: Author's Analysis.

2. Results

2.1. The Influence of AI in Driving Digital Financial Inclusion

Fintech companies are increasingly applying AI applications for many purposes which include but are not limited to the following: to manage and detect risk, risk measurement, fraud detection, consumer protection (Paul 2019). Other prominent areas of use include credit scoring, chatbots, capital optimization, market impact analysis, trade signalling, and 'reg tech' applications (Paul 2019).

2.1.1. Risk Detection, Management and Measurement

One major reason for many vulnerable groups—like women, youths and small businesses-like smallholder farmers—being excluded from the formal financial market in the traditional banking sector was driven by issues around risk (Beck et al. 2009). Many of these vulnerable groups were viewed as high risk due to the limited capability to detect and measure the risk among them (Park and Mercado 2015, 2018). Some of the factors that exacerbated this was lack of data (Park and Mercado

2018). However, AI is transforming financial inclusion through the widespread use of algorithms to automate risk detection management and measurement (Peric 2015; Muneeza et al. 2018). The use of AI is making it possible for the previously excluded groups to be able to access financial services using various digital tools such as cell phones or instruments like payment cards that can be used to connect with digital devices like point of sale terminals (Alameda 2020; Bill & Melinda Gates Foundation 2019).

In Kenya, M-Pesa, where M represents mobile while Pesa is another word for money in Swahili, is one of the mobile phone-based money transfer service operated by Safaricom which was able to offer payments services, and micro-financing service lunched in 2007 (Osah and Kyobe 2017; Burns 2018). The service has since spread to many countries which include Tanzania, Mozambique, DRC, Lesotho, Ghana, Egypt, Afghanistan, South Africa, India, Romania and Albania among many other countries (Jacob 2016; Burns 2018). The ability of a mobile device using AI intelligence could make it possible for people to make deposits, to withdraw money, to transfer money, pay for goods and services, to have access to credit and savings (Van Hove and Dubus 2019). This helps the low-income earners to be able to access these services which they could not access in the traditional banking system (Wang and He 2020). Additionally, through the use of AI intelligence, registration of accounts was achieved digitally; approximately 17 million accounts were registered in Kenya in its initial stages in 2012 while 7 million accounts were registered in Tanzania in 2016 (Van Hove and Dubus 2019; Wang and He 2020).

AI also plays an important role in preventing currency risk (Paul 2019). Through digital finance, individuals and small businesses (SMEs) have the option to add funds in the fiat currency which allows a shift in the volatility risk to the financial intermediary (FI) (Paul 2019). Many FIs are using bitcoin as a vehicle currency with the United States dollar as the dominant vehicle currency used in 88 per cent of trades (Global Partnership For Financial Inclusion 2016; Paul 2019). The use of bitcoin as a vehicle currency and block chain's platforms means that the recipient and the sender are not exposed to the volatility of virtual currency (Paul 2019). The ability to prevent risk is allowing small income earners to participate in the financial market as a result of the strength of AI technology (Alameda 2020). In short, financial markets are adopting more and more to AI to come with more exciting nimble models which are being utilized by financial experts to pinpoint trends, identify risks, conserve manpower and to ensure better information and for future planning (GPFI 2017).

2.1.2. AI and Information Asymmetry

The credit rationing theory credited to Stiglitz (Berardi 2011). This theory asserts that when information asymmetry (also referred to as imperfect information) is present in a competitive loan market, credit rationing will be the major feature of that credit market. Among a group of borrowers with fully observable and identical characteristics, some will receive loans while others will not get anything (Stiglitz 1989; Yuan et al. 2011). In the process, some disappointed borrowers will be more than willing to pay an interest rate which is more than the market interest rate. However, financial institutions will not be willing to respond to excess demand for loanable funds through raising the interest rate for borrowers (Stiglitz 1989). The major reason given was that in many circumstances when the interest rate is high, safer borrowers do not borrow as they are disuaded from borrowing (Yuan et al. 2011).

In addition, when the interest rate is high, borrowers will invest in high-risk projects which will limit the probability of paying back the loan (Berardi 2011). This condition will limit the participation of other potential players in the credit market. Accordingly, this explanation will help to explain why some economic agents will be excluded in the financial market and the increase in financial exclusion in the formal financial markets. According to the credit rationing theory, one of the major factors which cause the market to malfunction in developing nations is information asymmetry (Bell et al. 1997). It is believed that information asymmetry through adverse selection and moral hazards is the primary source of market inefficiencies (Bell et al. 1997). As a result of these inefficiencies in the market, high-risk borrowers like small scale farmers will be excluded from the group of potential borrowers

(Yuan et al. 2011). This will mark the reason many economic agents are financially excluded in the formal financial markets.

However, digital tools like AI can overcome the problem of information asymmetry (Kaya and Pronobis 2016). Digital financial inclusion through AI can have access to various online shopping platforms and various online social networks which produces a large amount of information on individuals which will help to do away with the problem of information asymmetry between financial institutions and individuals (Wang and He 2020; Yang and Zhang 2020). Digital tools improve access to credit to vulnerable groups especially those without collateral security based on big data analysis and cloud computing (Wang and He 2020). Many digital technologies which use AI technology utilize other credit score mechanisms to create collateral free-loan products (Matsebula and Yu 2017). One example of the bank which offered collateral-free loans was the Grameen Bank that won a Nobel Prize in 2006 together with Prof. Muhammad Yunus. The bank distributed collateral-free loans of united states dollars (USD) 24 billion to borrowers (Karlan and Morduch 2010; Wang and He 2020). In a way, AI solutions are assisting financial institutions and credit lenders to make smarter underwriting decisions through the use of many factors that assess accurately traditionally underserved borrowers in the credit decision-making process (Paul 2019).

2.1.3. AI and Customer Support and Helpdesk through Chatbots

Through the use of AI, banks are now adopting customer support and help desks which are impacting more on increasing efficiency and reducing the cost of customer support. Banks are offering an electronic virtual assistant (EVA). Moreover, with AI, financial institutions can provide personalized banking where chatbots and AI assistants, use AI to come up with personalized financial advice and natural language processing to provide instant, self-help customer service (Alameda 2020; Paul 2019).

Besides, AI is used as a relationship manager, banks are introducing chatbots for this purpose. This allows vulnerable households in rural areas to access financial advice and help which they cannot enjoy when dealing with human beings (Paul 2019). The HDFC bank of India has already introduced a chatbot for relationship manager purposes (Paul 2019). It is alleged that many bank staff have an urban orientation which makes it difficult for them to have the patience to deal and talk to the rural customers (Journal of Digital Banking 2019). Through the power of AI, banks can come up with natural regional language processing-based AI-trained robots for training and talking to the rural customers in regional language (Paul 2019). These robots explain various banking products offered by the bank, the robots can also explain the amount of debt rural customers have and even offer suggestions on the need to save (Siddiqui and Siddiqui 2017). AI-trained robots can become financial advisors to rural households (Deloitte 2018b; Paul 2019). As a result, AI is helping a lot to allow previously vulnerable groups to be able to access formal financial services (Wang and He 2020).

Additionally, some customers can access banking services through their mobile phones, where they can transact even while at home in the remote parts of their countries as long as they are connected to mobile networks. Furthermore, the use of AI can help a lot in account opening as individuals can open accounts or deposit through the use of phones (Paul 2019; Wang and He 2020). The use of blockchain has also allowed usability of accounts to be more effective; it takes approximately 10 minutes to transfer money which is faster than the conventional means mainly used in developing nations (Paul 2019). When using blockchain technology in digital finance payments, there is no need for payments to go through the national payments system and as a result, there is no need for physical branches. This makes payments more feasible as the cost of the transfer is the percentage of the value of the transferred (Paul 2019). On some instances, AI can facilitate quantitative trading. AI-powered computers can have a deep analysis of large and complex data sets very fast and more efficiently than human beings. This will result in automated trading which saves valuable time (Wang and He 2020).

2.1.4. Fraud Detection and Cybersecurity

Ramping up cybersecurity and fraud detection efforts is becoming a necessity for any financial institution or bank because of huge quantities of digital transactions which are carried out via online accounts every day, sometimes through mobile phone and applications (Lopes and Pereira 2019b; Paul 2019). AI is playing a big role in the improvement of security of online finance. The ability of AI to offer this kind of security to online finance makes it possible for the people at the bottom of the pyramid concerning financial inclusion to be able to participate in the formal financial sector (Reim et al. 2020). Further, fintech companies are using AI applications to advance consumer protection and user experience, manage risk, detect fraud in many countries (Paul 2019). Various national stock exchanges in many countries are contemplating the use machine learning to identify market patterns to improve monitoring and prevent manipulation of its high-frequency trading (HFT) markets (Journal of Digital Banking 2019; Deloitte 2018b). In reality, AI-enabled cybersecurity systems are increasingly being used to guard against and prevent possible security breaches. In addition, AI is influencing wealth management through robot advisors that provide automated financial planning services like tax planning advice, insurance advice, health, investment advice and many other crucial services (Journal of Digital Banking 2019). The HDFC bank of India is using AI for its Mobile Banking App, and On Chat, which makes use of Natural Language Processing where users can interact, confirm and pay for services within chat (Paul 2019).

2.2. Challenges of AI

Though AI is promising and doing a lot in fuelling digital financial inclusion, however, there are challenges associated with reaping the benefits from intelligent algorithms (Deloitte 2018b). Some of the challenges relate to data quality, responsibility requirements to roll out AI technology (Sundblad 2018). The prediction power of AI depends chiefly on the availability of quality data, However, limited availability of the right quality and quantity of data may act as an obstacle of the power of AI (Harkut and Kasat 2019). The prediction power of an algorithm depends highly on the quality of data fed as an input. Sometimes even in quality data, biases can be hidden (Sundblad 2018). In the financial sector, some reference data are often affected by quality issues (Sundblad 2018). The concept of AI is premised on having a data-quality program in place (Sundblad 2018). Moreover, the use of intelligent machines represents a challenge concerning liability (Harkut and Kasat 2019). The questions which remain unanswered are who/what shall be responsible in case something goes wrong? Financial institutions are sometimes reluctant to give machines full autonomy since the behavior of machines is not fully foreseeable (Deloitte 2018b; Sundblad 2018). In many cases, they tend to keep the human supervisor in place to validate the critical machine activities and decisions like blocking payments or releasing payments (Sundblad 2018). This, in a way, partially defeats the purpose of using machines in the first place (Sundblad 2018). In some instances, compliance and operational security standards are relatively strict and insufficient understanding of AI's inherent risks, the culture of the firm and regulation can all act as barriers to widespread adoption of AI in financial services firms (Harkut and Kasat 2019).

2.3. Conclusion and Policy Recommendations

The research was premised on investigating the impact of AI on digital financial inclusion. Digital financial inclusion is becoming central in the debate on how to ensure that people who are at the lower levels of the pyramid become financially active. On the other hand, fintech companies are taking advantage of the availability of AI to apply its applications to ensure that the goal of digital financial inclusion is realized that is to include groups of low-income earners, the poor, women, youths, small businesses in the mainstream financial market. The study discovered that AI has a strong influence on digital financial inclusion in areas related to risk detection, measurement and management, addressing the problem of information asymmetry, availing customer support and helpdesk through chatbots and fraud detection and cybersecurity. On the aspect of risk, AI is transforming financial inclusion

through the widespread use of algorithms to automate risk detection management and measurement. This enables vulnerable groups of women, youths and small businesses such as smallholder farmers, who were excluded from the formal financial market in the traditional banking sector driven by issues around risk, to access banking services. Considering issues related to information asymmetry, digital financial inclusion through AI can have access to various online shopping platforms and social networks which produces a large amount of information on individuals; this will help to do away with the problem of information asymmetry between financial institutions and individuals, thus increasing the financial inclusion. These are some of the areas where AI is influencing digital financial inclusion among many other issues discussed. It is also important to note that though many people have a lot of misgivings about AI in the industry 4.0, it is, however, important to notice that AI is providing subatantial assistance in the digital financial inclusion sphere. Therefore, this study recommends that financial institutions and non-financial institutions adopt and scale up the use of AI as it presents benefits in the quest to ensure that people who were previously unable to participate in the formal financial market can do so with ease.

Conflicts of Interest: The author declares no conflict of interest.

References

Alameda, Teresa. 2020. DATA, AI AND FINANCIAL INCLUSION: THE FUTURE OF GLOBAL BANKING—Responsible Finance Forum, Responsible Finance ForumBBVA 2020. Available online: https://responsiblefinanceforum.org/data-ai-financial-inclusion-future-global-banking/ (accessed on 12 May 2020).

An Editorial with 52 Researchers. 1994. Mainstream Science on Intelligence. pp. 13–23. Available online: http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.366.7808&rep=rep1&type=pdf (accessed on 19 May 2020).

Beck, Thorsten, Asli Demirgüç-Kunt, and Patrick Honohan. 2009. Access to financial services: Measurement, impact, and policies. *World Bank Research Observer* 24: 119–45. [CrossRef]

Beck, Thorsten, Haki Pamuk, Ravindra Ramrattan, and Burak R. Uras. 2018. Payment instruments, finance and development. *Journal of Development Economics* 133: 162–86. Available online: https://www.sciencedirect.com/science/article/pii/S0304387818300075 (accessed on 14 May 2020). [CrossRef]

Bell, Clive, T. N. Srintvasan, and Christopher Udry. 1997. Rationing, Spillover, and Interlinking in Credit Markets: The Case of Rural Punjab. *Oxford Economic Papers* 49: 557–85. Available online: https://academic.oup.com/oep/article-abstract/49/4/557/2361652 (accessed on 2 June 2020). [CrossRef]

Berardi, Marco. 2011. Credit Rationing in Markets With Imperfect Information. *SSRN Electronic Journal*. [CrossRef]

Bill & Melinda Gates Foundation. 2019. A G7 Partnership for Women's Digital Financial Inclusion in Africa. Available online: https://docs.gatesfoundation.org/Documents/WomensDigitalFinancialInclusioninAfrica_English.pdf?sf105300406=1 (accessed on 12 May 2020).

Bourreau, Marc, and Tommaso Valletti. 2015. Enabling Digital Financial Inclusion through Improvements in Competition and Interoperability: What Works and What Doesn't? Available online: http://www.cgdev.org/publication/enabling-digital-financial-inclusion-through-improvements-competition- (accessed on 18 May 2020).

Burns, Scott. 2018. M-Pesa and the "Market-Led" Approach to Financial Inclusion. *Economic Affairs* 38: 406–21. [CrossRef]

Chatterjee, Prabirendra, and Sudipta Sarangi. 2006. The Economics of Microfinance. *Southern Economic Journal* 73: 259. [CrossRef]

Chu, A. B. 2018. Mobile Technology and Financial Inclusion. In *Handbook of Blockchain, Digital Finance, and Inclusion, Volume 1: Cryptocurrency, FinTech, InsurTech, and Regulation*. Cambridge: Academic Press, pp. 131–44. [CrossRef]

Colom, Roberto, Sherif Karama, Rex E. Jung, and Richard J. Haier. 2010. Human intelligence and brain networks. *Dialogues in Clinical Neuroscience* 12: 489–501. Available online: https://www.ncbi.nlm.nih.gov/pmc/articles/pmc3181994/ (accessed on 19 May 2020).

David-West, Olayinka. 2015. The path to digital financial inclusion in Nigeria: Experiences of Firstmonie. *Journal of Payments Strategy & Systems* 9: 256–73. Available online: https://www.ingentaconnect.com/content/hsp/jpss/2016/00000009/00000004/art00007 (accessed on 18 May 2020).

Dawei, Liu, Hu Anzi, and Li Gen. 2018. Big Data Technology: Application and Cases. In *Handbook of Blockchain, Digital Finance, and Inclusion*. Amsterdam: Elsevier Inc., pp. 65–82. [CrossRef]

Deloitte. 2018a. The Fourth Industrial Revolution Is Here—Are South African Executives Ready? Available online: https://www2.deloitte.com/za/en/pages/about-deloitte/articles/gx-preparing-tomorrow-workforce-for-the-fourth-industrial-revolution.html (accessed on 13 May 2020).

Deloitte. 2018b. Challenges Artificial Intelligence in Financial Services—Deloitte Forward, Deloitte. Available online: https://www.deloitteforward.nl/en/artificial-intelligence/challenges-to-widespread-artificial-intelligence-in-financial-services/ (accessed on 2 June 2020).

Demirguc-Kunt, Asli, Leora Klapper, Saniya Ansar, and Aditya Jagati. 2017. Making It Easier to Apply for a Bank Account A Study of the Indian Market. Available online: https://elibrary.worldbank.org/doi/abs/10.1596/1813-9450-8205 (accessed on 12 May 2020).

Dubus, Antoine, and Leo Van Hove. 2017. M-PESA and Financial Inclusion in Kenya: Of Paying Comes Saving? Available online: https://hal.archives-ouvertes.fr/hal-01591200 (accessed on 14 May 2020).

Frank, Morgan R. 2019. The Evolution of AI Research and the Study of Its Social Implications. MIT MEDIA LAB 2019. Available online: https://medium.com/mit-media-lab/the-evolution-of-ai-research-and-the-study-of-its-social-implications-4a9598b3d7db (accessed on 25 May 2020).

Global Partnership For Financial Inclusion. 2016. G20 High-Level Principles for Digital Financial Inclusion. *Global Partnership for Financial Inclusion*, 3–23. Available online: https://www.gpfi.org/sites/gpfi/files/documents/G20 (accessed on 12 May 2020).

Gomber, Peter, Jascha-Alexander Koch, and Michael Siering. 2017. Digital Finance and FinTech: Current research and future research directions. *Journal of Business Economics* 87: 537–80. [CrossRef]

Gottfredson, Linda S. 1997. Why g matters: The complexity of everyday life. *Intelligence* 24: 79–132. [CrossRef]

G20 Global Partnership for Financial Inclusion (GPFI). 2017. Digital Financial Inclusion: Emerging Policy Approaches. Available online: https://www.gpfi.org/sites/gpfi/files/documents/DigitalFinancialInclusion-CompleteReport-Final-A4.pdf (accessed on 13 May 2020).

Harkut, Dinesh G., and Kashmira Kasat. 2019. Introductory Chapter: Artificial Intelligence—Challenges and Applications. In *Artificial Intelligence—Scope and Limitations*. London: IntechOpen. [CrossRef]

Hassani, Hossein, Emmanuel Sirimal Silva, Stephane Unger, Maedeh TajMazinani, and Stephen Mac Feely. 2020. Artificial Intelligence (AI) or Intelligence Augmentation (IA): What Is the Future? *Ai* 1: 143–55. [CrossRef]

Hotchkiss, Griffin, and David Lee Kuo Chuen. 2018. From the Ground Up: The Financial Inclusion Frontier. In *Handbook of Blockchain, Digital Finance, and Inclusion*. Amsterdam: Elsevier Inc., pp. 405–29. [CrossRef]

Jacob, Frank. 2016. The Role of M-Pesa in Kenya's Economic and Political Development. In *Kenya After 50*. New York: Palgrave Macmillan US, pp. 89–100. [CrossRef]

Journal of Digital Banking. 2019. The Digitalisation of Payments in South-East Asia: Ingenta Connect, ingentaconnect.com. Available online: https://www.ingentaconnect.com/content/hsp/jdb001/2019/00000004/00000001/art00008 (accessed on 2 June 2020).

Karlan, Dean, and Jonathan Morduch. 2010. Access to finance. In *Handbook of Development Economics*. Amsterdam: Elsevier, vol. 5, pp. 4703–84. [CrossRef]

Kaya, Devrimi, and Paul Pronobis. 2016. The benefits of structured data across the information supply chain: Initial evidence on XBRL adoption and loan contracting of private firms. *Journal of Accounting and Public Policy* 35: 417–36. [CrossRef]

Killeen, Alyse, and Rosanna Chan. 2018. Global Financial Institutions 2.0. In *Handbook of Blockchain, Digital Finance, and Inclusion*. Amsterdam: Elsevier Inc., pp. 213–42. [CrossRef]

Koh, Francis, Kok Fai Phoon, and Cao Duy Ha. 2018. Digital Financial Inclusion in South East Asia. In *Handbook of Blockchain, Digital Finance, and Inclusion*. Cambridge: Academic Press, pp. 387–403. [CrossRef]

Lauer, Kate, and Timothy Lyman. 2015. *Digital Financial Inclusion: Implications for Customers, Regulators, Supervisors, and Standard-Setting Bodies*. Washington, DC: The World Bank.

Legg, Shane, and Marcus Hutter. 2007. A Collection of Definitions of Intelligence. Available online: www.idsia.ch/$\sim$shanewww.hutter1.net (accessed on 19 May 2020).

Levin, Richard B., Peter Waltz, and Holly LaCount. 2018. Betting Blockchain Will Change Everything-SEC and CFTC Regulation of Blockchain Technology. In *Handbook of Blockchain, Digital Finance, and Inclusion*. Amsterdam: Elsevier Inc., pp. 187–212. [CrossRef]

Liao, Gaoke, Dequan Yao, and Zhihao Hu. 2020. The Spatial Effect of the Efficiency of Regional Financial Resource Allocation from the Perspective of Internet Finance: Evidence from Chinese Provinces. *Emerging Markets Finance and Trade* 56: 1211–23. [CrossRef]

Lopes, Jorge, and José Luís Pereira. 2019a. Blockchain projects ecosystem: A review of current technical and legal challenges. In *Advances in Intelligent Systems and Computing*. Cham: Springer, pp. 83–92. [CrossRef]

Lopes, Jorge, and José Luís Pereira. 2019b. Blockchain technologies: Opportunities in healthcare. In *Advances in Intelligent Systems and Computing*. Cham: Springer, pp. 435–42. [CrossRef]

Loufield, Ethan, Dennis Ferenzy, and Tess Johnson. 2018. Accelerating Financial Inclusion with New Data. The Mainstreaming Financial Inclusion: Best Practices Series. pp. 1–30. Available online: https://medium.com/nest-ideas/accelerating-financial-inclusion-with-blockchain-6eb658fbfb0e (accessed on 12 May 2020).

Mamoshina, Polina, Lucy Ojomoko, Yury Yanovich, Alex Ostrovski, Alex Botezatu, Pavel Prikhodko, Eugene Izumchenko, Alexander Aliper, Konstantin Romantsov, and Alexander Zhebrak. 2018. Converging blockchain and next-generation artificial intelligence technologies to decentralize and accelerate biomedical research and healthcare. *Oncotarget* 9: 5665–90. [CrossRef] [PubMed]

Matsebula, Velenkosini, and Derek Yu. 2017. *Financial Inclusion in South Africa: A NIDS Data Analysis of Household Access and the Usage of Financial Services and Products*. Cape Town: Department of Economics, University of the Western Cape, pp. 1–21.

Moloi, David Mhlangaand Tankiso. 2020. COVID-19 and the Digital Transformation of Education: What we are learning in South Africa. *Preprints*. [CrossRef]

Muneeza, Aishath, Nur Aishah Arshad, and Asma Tajul Arifin. 2018. The Application of Blockchain Technology in Crowdfunding: Towards Financial Inclusion via Technology. *International Journal of Management and Applied Research* 5: 82–98. [CrossRef]

Osah, Olam, and Michael Kyobe. 2017. Predicting user continuance intention towards M-pesa in Kenya. *African Journal of Economic and Management Studies* 8: 36–50. [CrossRef]

Ozili, Peterson K. 2018. Impact of digital finance on financial inclusion and stability. *Borsa Istanbul Review* 18: 329–40. [CrossRef]

Park, Cyn-Young, and Rogelio Mercado. 2015. Financial Inclusion, Poverty, and Income Inequality in Developing Asia. *SSRN Electronic Journal*. [CrossRef]

Park, Cyn-Young, and Rogelio Mercado. 2018. Financial inclusion, poverty, and income inequality. *Singapore Economic Review* 63: 185–206. [CrossRef]

Paul, Sandeep. 2019. Use of Blockchain and Aritificial Intelligence to Promote Financial Inclusion in India Smita Miglani Indian Council for Research on International Economic Relations. Available online: https://economictimes (accessed on 28 May 2020).

Peric, Kosta. 2015. Digital financial inclusion. *Journal of Payments Strategy & Systems* 9: 212–14. Available online: https://www.ingentaconnect.com/content/hsp/jpss/2015/00000009/00000003/art00001 (accessed on 11 May 2020).

Rathi, Vandana. 2016. India amidst digital banking and financial inclusion—A review. *International Journal of Management and Social Sciences* 6: 24–28. Available online: http://journals.foundationspeak.com/index.php/ijmss/article/view/340 (accessed on 25 May 2020).

Reim, Wiebke, Josef Åström, and Oliver Eriksson. 2020. Implementation of Artificial Intelligence (AI): A Roadmap for Business Model Innovation. *AI* 1: 180–91. [CrossRef]

Salampasis, Dimitrios, and Anne-Laure Mention. 2018. FinTech: Harnessing Innovation for Financial Inclusion. In *Handbook of Blockchain, Digital Finance, and Inclusion*. Cambridge: Academic Press, pp. 451–61. [CrossRef]

Sapovadia, Vrajlal. 2018. Financial Inclusion, Digital Currency, and Mobile Technology. In *Handbook of Blockchain, Digital Finance, and Inclusion*. Amsterdam: Elsevier Inc., pp. 361–85. [CrossRef]

Sarma, Mandira. 2015. Measuring financial inclusion. *Economics Bulletin* 35: 604–611.

Schwab, Klaus. 2015. The Fourth Industrial Revolution. What It Means and How to Respond? Snapshot. Available online: https://www.weforum.org/agenda/2016/01/the-fourth-industrial-revolution-what-it-means-and-how-to-respond/ (accessed on 25 May 2020).

Schwab, Klaus. 2019. Davos Manifesto 2020: The Universal Purpose of a Company in the Fourth Industrial Revolution, World Economic Forum. Available online: http://www.worldacademy.org/files/global_leadership/papers/Davos_Manifesto_2020.pdf (accessed on 5 May 2020).

Siddiqui, Taufeeque, and Kashif Iqbal Siddiqui. 2017. Exploring Linkages between Telecom and Financial Inclusion: An Innovative Strategy for Success. In Proceedings of the International Conference on Strategies in Volatile and Uncertain Environment for Emerging Markets, New Delhi, India, 14–15 July 2017; pp. 830–37, ISBN 978-93-83893-05-8. Available online: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3392300 (accessed on 5 May 2020).

Snyderman, Mark, and Stanley Rothman. 1987. Survey of Expert Opinion on Intelligence and Aptitude Testing. *American Psychologist* 42: 137–44. [CrossRef]

Stiglitz, Joseph E. 1989. Chapter 13 Imperfect information in the product market. *Handbook of Industrial Organization* 1: 769–847. [CrossRef]

Sundblad, W. 2018. Data is The Foundation for Artificial Intelligence and Machine Learning, Forbes. Available online: https://www.forbes.com/sites/willemsundbladeurope/2018/10/18/data-is-the-foundation-for-artificial-intelligence-and-machine-learning/#12324a7751b4 (accessed on 2 June 2020).

The World Bank. 2020. Digital Financial Inclusion. Available online: https://www.worldbank.org/en/topic/financialinclusion/publication/digital-financial-inclusion (accessed on 12 May 2020).

Van Hove, Leo, and Antoine Dubus. 2019. M-PESA and financial inclusion in Kenya: Of paying comes saving? *Sustainability* 11: 568. [CrossRef]

Visser, W., and C. K. Prahalad. 2013. The Fortune at the Bottom of the Pyramid. In *The Top 50 Sustainability Books*. pp. 200–203. Available online: https://www.csrwire.com/pdf/Prahalad-excerpt-001-022.pdf (accessed on 5 May 2020). [CrossRef]

Wang, Xue, and Guangwen He. 2020. Digital financial inclusion and farmers' vulnerability to poverty: Evidence from rural China. *Sustainability* 12: 1668. [CrossRef]

Yang, Liu, and Youtang Zhang. 2020. Digital Financial Inclusion and Sustainable Growth of Small and Micro Enterprises—Evidence Based on China's New Third Board Market Listed Companies. *Sustainability* 12: 3733. [CrossRef]

Yuan, Yan, Youxin Hu, and Ping Gao. 2011. Farmers' Choice and Informal Credit Markets in China. Available online: https://ageconsearch.umn.edu/record/103887/ (accessed on 2 June 2020).