Introducing the Concept of Intelligent Financial Inclusion

Anam Fazal
Lecturer, Lahore Garrison University, Lahore, Pakistan.
Ph.D. scholar, School of Business Administration and Economics, Lahore, Pakistan.

Alia Ahmed
Dean & Professor, School of Business Administration and Economics, Lahore, Pakistan.

Abstract
Financial inclusion is the safe and timely access to formal financial services for people at affordable costs. Various barriers of the legacy financial system hinder the involvement of all segments of the population in the financial sector. The journey from financial exclusion to financial inclusion has to be achieved with the implementation of technological breakthroughs. Covid-19 has also raised the need for technology in all sectors of the economy. This research paper introduces the concept of intelligent financial inclusion, which is providing financial services to people with the help of intelligent systems. This intelligent system will take the concepts from the human mind, cognitive sciences, and artificial intelligence tools and techniques. To achieve the optimal level of financial inclusion, economies must shift their financial sector from traditional means to intelligent financial systems. In this way, intelligent financial inclusion will achieve the target of involving all people in the financial sector.

Keywords:
Financial exclusion; COVID-19, Intelligent financial inclusion.

1. Introduction

According to economic theory, financial exclusion in an economy results in inequalities among the masses (Kling et al., 2020). On the other hand, financial inclusion greatly contributes to the well-being of economies. It provides opportunities to reduce poverty by unblocking opportunities for underprivileged groups of society (Koomson et al. 2020; Omar and Inaba, 2020; N'dri and Kakinaka, 2020), helping people participate in financial and ultimately, other sectors of the country. It also improves the gender quality and level of education.

For the background of financial inclusion, there is a need to discuss its relationship with microfinance. The concept of microfinance was developed in the 1970s to expand credit in society. Around 2010, the hype of micro-financial institutions began to lower owing to certain reasons like the inability to combat poverty and women empowerment or high-interest rates (Mader, 2017). Owing to such reasons, the concept of financial inclusion grabbed more attention with its broader scope and inevitable significance for society. Financial inclusion greatly contributes to recovery from global economic and health crises such as COVID-19 (UNSGSA, 2021). This raises the need to involve people and businesses in the financial sector, so they can play their role in the growth of economies. Thus, financial inclusion is vital for improving the well-being and standard of life as well as for meeting long-term economic goals.

There are various problems of the legacy financial system that put a constraint on involving all people in the financial sector. Removal of such problems can lead economies to achieve financial inclusion. Despite the importance of financial inclusion for the growth of economies, there are certain factors and challenges in the financial sector that hinder the participation of people in the financial sector (Barruetabeña, 2020; Schuetz & Venkatesh, 2019). These factors are considered barriers to financial inclusion which deprive people of using basic financial services. For instance, a person may be unable to make financial decisions wisely because of financial illiteracy, as a lack of knowledge and skills leads to wrong choices about wealth (Yaroslava et al., 2018). Such decisions cause a loss of money which discourages financial behaviors. As a result, people are reluctant to participate in investment and financial products (Bansala, 2014). Thus, financial illiteracy becomes a barrier to financial inclusion. Like financial illiteracy, there are various other barriers to financial inclusion like high transactions and operations costs (Schuetz & Venkatesh, 2019), manual processes (Dong, 2018), and poor credit risk analysis (Biallas & O'Neill, 2020). Like these issues, there can be many other barriers in the financial sector. Policymakers and governments adopt different measures to solve the problems of the financial sector. Despite such efforts, the economies of the world have not reached the optimal level of financial inclusion (Ozili, 2020a). There remain many inefficiencies in the financial sector like manual processes and high costs due to which it does not make its maximum contribution to economic growth (Demiguc-Kunt et al., 2017; Anagnoste, 2017).

However, the modern era of Fintech, or the technological revolution has had a tremendous effect on

Manuscript received April 5, 2023
Manuscript revised April 20, 2023
https://doi.org/10.22937/IJCSNS.2023.23.4.13

the financial sector also. It has changed the ways of circulation of finance in the country. Fintech opportunities like blockchain have the potential to resolve problems of financial exclusion like high costs, financial illiteracy, inappropriate products, and high costs (Schuetz & Venkatesh, 2019). More specifically, Artificial Intelligence (AI) and Machine Learning (ML) are affecting rapidly in bringing transformation in the financial sector. AI promises to provide solutions to all the problems which hinder the provision of finance to all segments of society (Zetzsch et al. 2020).

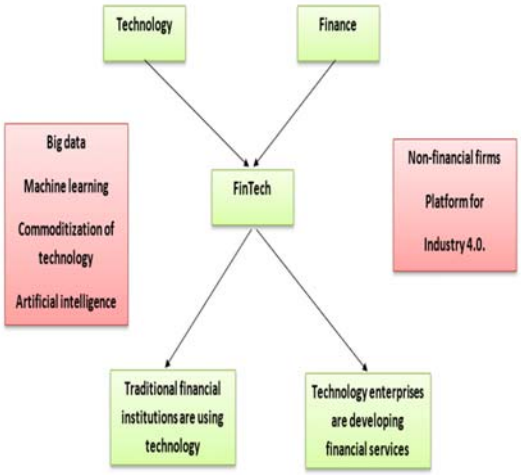


Figure 1: Description of FinTech (Chang, 2020)

Considering this discussion, the purpose of this research paper is to introduce the concept of intelligent financial inclusion. This concept is the vision of the future and explains the evolution of financial inclusion. Intelligent financial inclusion is the implementation of characteristics of the human mind, cognitive sciences, and AI tools and applications in the financial sector to provide efficient and suitable services by removing the barriers of the traditional financial system. The focus of AI-assisted financial applications should be the barriers that are a problem for our legacy financial systems. In other words, advancements in technology in the financial sector should be oriented towards the removal of these barriers. Otherwise, such developments will only lead to chaos and various challenges.

Thus, this research paper explains the importance of linking AI with financial inclusion by mentioning real-world examples of AI for financial inclusion. The focus is to understand the need for AI as a solution to the barriers of financial inclusion. Most importantly, it introduces the concept of intelligent financial inclusion which is a new term in the field of finance and computer.

After this introduction, section 2 will discuss the role of AI in promoting financial inclusion. Furthermore, a brief description of barriers of financial inclusion and AI as their solution has been made. Section 3 builds the concept of intelligent financial inclusion. Concluding remarks are presented in section 4.

2. Role of AI in financial inclusion

Industry 4.0., big data, the Internet of Things (IoT), artificial intelligence (AI), and machine learning (ML) have revolutionized the traditional operations of all sectors of an economy. AI is an intelligent system that creates and analyzes data even without programming. It has the capability of decision-making with the help of insights from big data sets (Hassani et al., 2020). It encompasses both self-learning and analyzing abilities to perform various tasks (Truby et al., 2020). AI takes the core concept of machine development based on human intelligence to solve complex problems around people from healthcare to macro-economic issues (Goralski & Tan, 2020). ML is one of the sub-fields of computer science and can learn without explicit programming. ML constructs algorithms by learning and predicting from data (Ongsulee, 2017). AI includes ML and interprets, automates, and takes decisions. Concisely, ML combined with decision and action makes AI (Decosmo, 2019).

With the emergence of AI, there has been a paradigm shift in the analysis of many issues of economies; Industry 4.0., computational powers, use of big data, and ML algorithms have changed the ways of operations from data entry to policymaking (Ozili, 2021). The field of AI is progressing rapidly and ensures transformations in all sectors of the economy. This change is driven by growing AI algorithms, fast competition, changing interest of customers in digital products, and increased investment in AI. For the provision of financial services to poor people, AI can serve the role of a game-changer (Kshetri, 2021).

The financial sector is greatly affected by this revolution of technology (Agidi, 2020; Biallas and O'Neill, 2020; How et al., 2020). AI has occupied many areas of financial services from account opening to investment decisions. AI and ML capabilities have transformed the financial sector through forecasting, natural language processing, image recognition, and anomaly detection (IMF, 2021). These changes have grabbed the attention of researchers and financial regulators toward financial inclusion (Senyo & Osabutey,

2020). AI has proved to be a promising solution to many barriers to financial inclusion (Barruetabeña, 2020).

Advancements in the field of computer science especially AI have come forward to address such problems (Decosmo, 2019). AI is playing its role in advancing financial inclusion in countries (Kshetri, 2021; Mhlanga, 2020). One significant example is the solution to the barrier of manual processes. AI has automated the processes of stock markets and has the potential to deal with huge data from various markets. Such automation has reduced the chances of wrong decisions and business being performed in milliseconds (Donepudi, 2019; Buchanan, 2019). On the other side, AI has proved to be a solution to credit risk analysis (Wall, 2018). AI-based digital personal lending helps such customers by generating their profiles when they do not have borrowers' histories and are unable to access traditional banks. Mexico's Kueski (2021) advances loans to customers who are not eligible for traditional loan services. It uses AI and ML to identify potential risk customers with the help of their profiles and data from other sources also. In this way, it is helping in the involvement of all customers in the financial system and fraud reduction at the same time. With the help of AI, fraud and traditional risks in the financial sector have also been reduced (Al-Blooshi & Nobanee, 2020). Fraud detection systems activate cybersecurity mechanisms upon detection of some malicious activity. Ant Group employs deep learning technology to detect fraud. Their technology implementation has resulted in only one loss of $1 million (Perez & Soo, 2017).

AI is a promising solution to barriers of financial inclusion. For solving the problems created by manual processes, the only key is the automation of systems. Robotic process automation (RPA) is considered the best solution to the problems of manual processes (Anagnoste, 2017). Transferring a fund manually employs 150+ keystrokes, consuming a time of 8-10 minutes. Automation by robotics process takes less than 1 minute for such exchange (Mancher, Huff, Grabowski, & Thomas, 2017). High transaction and operation costs are the most significant barriers to financial inclusion. The barrier of high costs can be removed by introducing tech-oriented products in the market and by applying AI techniques in finance. Technology plays a vital role in the reduction of operational costs (Masood & Sonntag, 2020) and serves as a remedy for the problem of financial exclusion (Schuetz & Venkatesh, 2019). People do not opt for financial services like insurance due to high costs. These costs are reduced by the introduction of technology. As Tulasi et al. (2017) stated technological breakthroughs have worked dramatically to decrease fixed transactional costs of financial products in India. AI assists in reducing credit risk analysis for financial institutions. Public data such as data from social media websites and registered companies aid in credit analysis using AI techniques. Thus, AI and machine learning greatly influence credit analysis by financial institutions (Mhlanga, 2020). It helps in the establishment of the creditworthiness of customers by adopting alternative techniques and using data from different means. Customer data is used to form scorecards that are fed to ML systems. Then, improvement in algorithms and data points serves as a predictive tool for the creditworthiness of customers (Biallas & O'Neill, 2020).

3. Intelligent financial inclusion

Financial inclusion is the safe and timely access to appropriate and low-cost formal financial services (Sahay, 2015; AFI, 2018) by all segments of society including the poor (Rangarajan, 2008; United Nations, 2016a; N'dri & Kakinaka, 2020), underprivileged people and women and aims at reducing poverty and enhancing economic growth (Ozili, 2018). It is considered the key component of inclusive development (Triki and Faye, 2013; Demirguc-Kunt, Klapper et al., 2017). According to the Financial Stability Board (FSB, 2017), financial technology is "…technologically enabled financial innovations that could result in new business models, applications, processes, or products with an associated material effect on financial markets and institutions and the provision of financial services". Some well-known FinTech companies are providing AI-based solutions to customers like AI-based customer service chatbot by Ant Group (China), banking chatbot Leo by UBA (Nigeria), chatbot assistant Zuri by Safaricom (Kenya), and Tymebank interaction with customers via kiosks (South Africa) (Kshetri, 2021). One example is Nigeria in which banks are using technologies to ensure financial inclusion. People are encouraged to participate in formal financial services by banks through mobile apps, USSD codes (Global System for Mobile Communication-GSM service), mobile banking technology serving as agency banking, and third-party payment apps (Wayne et al., 2020).

According to the World Bank (2021), digital financial inclusion is the digital access to basic financial services by all segments of the population. These financial services must be affordable and suitable to customers' needs. Financial inclusion in an economy is promised by technological infrastructure, customers' inclination towards technology, access to the Internet and smartphones, and the availability of bank branches

(Wayne et al., 2020). The underlying reason behind this linkage is that traditional financial institutions are reluctant in providing services to low-income groups due to the small amount of loans and associated high transaction costs (Kshetri , 2019). Mhlanga (2020) discussed that AI is a strong driver of digital financial inclusion and serves as a solution to problems of the traditional financial sector like information asymmetry, risk and fraud detection, and addressing customer support problems through chatbots, etc. By using documentary analysis, this study recommended the adoption of AI by financial institutions and governments. This will help in the accomplishment of goals of financial inclusion and will enable vulnerable groups of society to access formal financial services. For including all those people who are left out to adopt universal policies for sustainable development, technology-driven financial inclusion is one of the measures suggested by the United Nations (United Nations, 2016b).

Financial institutions are working to narrow the gap between the financial sector and the underserved population with the help of AI. The fourth industrial revolution is helping in this pyramid shift also. Moreover, AI started to move at a faster pace around 2011 when companies like Google, Facebook, Microsoft, and IBM started investing in it. Another enforcement for accepting technology in finance is COVID-19 which has made it indispensable for traditional financial institutions to move without tech in the world. During the pandemic, companies like Amazon or Alibaba made billions of returns by embracing technology and recording transactions digitally. This has also set an example for others in the traditional financial system to move towards digital financial inclusion.

Various factors serve as drivers of implementing AI in financial inclusion. Industry 4.0., COVID-19, and the investment of major fintech companies towards AI are some of the main factors contributing to the boom of AI in finance (Mhlanga, 2020). Technological innovation has enabled the financially excluded population to be involved in the formal financial sector (Barruetabeña, 2020). Implementation of AI in traditional financial institutions can help financial institutions to know about potential customers. Financial service providers can predict the response of customers about their products with the help of AI. How et al. (2020) used a human-centric AI-based approach to analyze the possible outcomes of prospective customers' intentions towards financial products. This study explained that AI can be used as a social good for people who are unfamiliar with computers and technology. Empirical results of this study suggested that AI-Thinking can provide a better understanding for paving the way for financial inclusion.

Intelligence is defined as the ability to learn and think, whereas, Intelligence science is an interdisciplinary field and it takes the concepts from brain science, cognitive science, and artificial intelligence (Shi, 2009). Russell & Norvig (2003) mentioned four modes of AI: Acting humanly, thinking humanly, thinking rationally, and acting rationally. Antsaklis (1999) explained intelligent control as a discipline where control methods are capable of characteristics of human intelligence like learning, planning, and adapting to change. Such intelligent control takes the concepts from the fields of computers, operations, mathematics, and biological systems. This system has found applications in many fields from robotics and communications to fuzzy controls, expert and hybrid systems. Practically, DARPA submarine automation is one of the examples. Intelligent products can adapt to changes in the environment (Meyer, Framling, & Holmstrom, 2009).

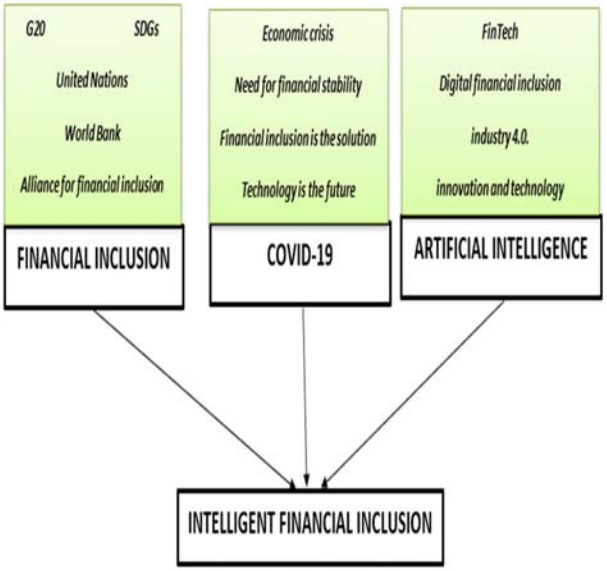
Intelligent systems are becoming more and more crucial with the expansion of corporate databases. A human mind can handle around 50,000 words only but an intelligent database aims at defining data more simply, and efficiently for further processing. The technology of such systems is a combination of graphical user interfaces, automatic discovery, hypermedia, traditional databases, and object orientation. All these characteristics are missing in traditional systems. Thus, an intelligent database takes the core concepts of computational, linguistic, cognitive, and mathematical tools and provides useful data results from large databases (Parsaye & Chignell, 1993).

By applying such concepts of intelligent systems for financial inclusion, people will be able to live in a world of intelligent financial inclusion. Intelligent financial inclusion will take the concepts from human intelligence and computer sciences and will play its role in providing financial services. This system will learn from the existing data and parameters and will predict solutions and their suitability for customers. Such a system is the only solution to escape from financial inclusion and to reach an optimal level of financial inclusion. The result of this intelligent financial inclusion will be the efficient delivery of financial services and products to all segments of society at affordable cost, accompanied by the reduction of frauds, malpractices, and delivery of the right services to the right people and places.

AI has a strong effect on financial inclusion by mitigating its barriers. Concludingly, this research paper stated that the financial sector should scale up the use of AI as it ensures the participation of all people in formal financial markets. There must be a shift from digital to intelligent financial inclusion. For this, there is a need to introduce the concept of intelligent financial inclusion

which aims at providing AI-assisted financial inclusion solutions for removing the barriers of the traditional financial sector. In this way, intelligent financial inclusion will be the future, a better world to live in!

Figure 2: Inspiring factors for intelligent financial inclusion



4. Concluding remarks

The economic crisis caused by COVID-19 demands financial stability which can be achieved by financial inclusion (Vo et al., 2021). Financial institutions are using AI applications to handle a large volume of loan applications, recovery, and fraud detection during pandemics (IMF, 2021). COVID-19 has also necessitated the payment's transition from cash to digital means. The risk of its spread by cash transactions and government transfers to the public in emergency conditions has encouraged the use of digital applications (Barajas, Beck, Belhaj, & Naceur, 2020).

The world is seeing tremendous changes in countries' social, cultural, political, and economic sectors. Thanks to AI and ML. Humans can think, analyze and process data but they can't process large amounts of data meeting all requirements of customers and legislation. Specifically, in the financial sector, AI is helping in a paradigm shift by expanding financial services to all segments of society. The main target of this digital financial inclusion is the involvement of the poor and vulnerable groups in the financial system of the economy. Traditional financial institutions like banks do not find themselves at ease in advancing loans to such groups of society due to the high costs associated with the processing of loans (Kshetri, 2019). This makes it indispensable for countries to introduce AI-based financial inclusion.

A significant change in the financial sector driven by AI and ML algorithms will expand the level of financial inclusion, by involving existing sub-systems of the economy. AI tools and techniques may impose regulations on economic agents, modernize financial services, or increase social well-being. In this way, it can achieve financial inclusion by developing inter-relationships among its sub-systems. The fact cannot be denied that the world has seen tremendous changes in financial services due to AI tools and techniques. However, such efforts will not generate maximum output unless they are directed toward the removal of all barriers to financial inclusion. Considering this problem, this research seeks to identify barriers to financial inclusion and proposes AI as a solution to these barriers. Removal of such barriers by AI will lead to intelligent financial inclusion which assures the achievement of human development goals and the growth of economies. The adoption of financial inclusion while eliminating its barriers with the help of AI will provide INTELLIGENT FINANCIAL INCLUSION to the world. This intelligent financial inclusion is a promise to achieve human development goals and the growth of economies.

References

[1] AFI. (2018). Fintech for Financial Inclsuion: A Framework for Digital Financial Transformtion. *Alliance for Financial Inclusion(AFI) Special Report*.

[2] Agidi, R. C. (2020). Artificial Intelligence in Nigeria Financial Sector. *International Journal of Electronics and Information Engineering*, 11 (1), 40-47. doi: 10.6636/IJEIE.201909 11(1).05.

[3] Al-Blooshi, L., & Nobanee, H. (2020). Applications of Artificial Intelligence in Financial Management Decisions: A Mini-review. *SSRN Electronic Journal*, doi: 10.2139/ssrn.3540140.

[4] Allen, F., Demirguc-Kunt, A., Klapper, L., & Peria, M. (2016). The Foundations of Financial Inclusion: Understanding Ownership and Use of Formal Accounts. *Journal of Financial Intermediation*, doi: 10.1016/j.jfi.2015.12.003.

[5] Anagnoste, S. (2017). Robotic Automation Process - The Next Major Revolution in Terms of Back Office Operations Improvement. *Proceedings of the International Conference on Business Excellence* (pp. 677-686). De Gruyter. doi: 10.1515/picbe-2017-0072.

[6] Antsaklis, P. J. (1999). Intelligent Control. *Encyclopedia o f Electrical a nd Electronics Engineering John, Wiley & Sons, Inc*., 10, 493-503. .

[7] Arner, D. W., Buckley, R. P., Zetzsche, D. A., & Veidt, R. (2020). Sustainability, FinTech and Financial Inclusion. *European Business Organization Law Review*, 21, 7-35. doi:10.1007/s40804-020-00183-y.

[8] Bandura, W. N., & Dzingirai, C. (2019). Financial Development and Economic Growth in Sub Saharan Africa: The Role of Institutions. *PSL Quarterly Review*, 72 (291), 315-334. doi: 10.13133/2037-3643_72.291_5.

[9] Bansala, S. (2014). Perspective of Technology in Achieving Financial Inclusion in Rural India. *Procedia Economics and Finance*, 11, 472-480. (http://creativecommons.org/licenses/by-nc-nd/3.0/).

[10] Barajas, A., Beck, T., Belhaj, M., & Naceur, S. B. (2020). Financial Inclusion: What Have We Learned So Far? What Do We Have To Larn? *IMF Working Paper No. 20/157*, https://www.imf.org/en/Publications/WP/Issues/2020/08/07/Financial-Inclusion-What-Have-We-Learned-So-Far-What-Do-We-Have-to-Learn-49660.

[11] Barruetabeña, E. (2020). Impact of New Technologies on Financial Inclusion. *Economic Bulletin*, Electronic copy available at: https://ssrn.com/abstract=3678000.

[12] Biallas, M., & O'Neill, F. (2020). Artificial Intelligence Innovation in Financial Services. *IFC: World Bank*, Note 85. www.ifc.org/thoughtleadership.

[13] Bose, S., Saha, A., Khan, H. Z., & Islam, S. (2017). Non-Financial Disclosure and Market-Based Firm Performance: The Initiation of financial inclusion. *Journal of Contemporary Accounting & Economics*, doi:10.1016/j.jcae.2017.09.006.

[14] Buchanan, B. G. (2019). Artificial Intelligence in Finance. *The Alan Turing Institute*, doi: 10.5281/zenodo.2612537.

[15] Burjorjee, D. M., & Scola, B. (2015). *A Market Systems Approach to Financial Inclusion: Guidelines for Funders.* Washington, DC.: Consultative Group to Assist the Poor (CGAP).

[16] Chao, X., Kou, G., Peng , Y., & Viedma, E. H. (2021). Large-scale group decision-making with non-cooperative behaviors and heterogeneous preferences: An application in financial inclusion. *European Journal of Operational Research* , 288 (271-293). doi: 10.1016/j.ejor.2020.05.047.

[17] Chen, Z., & Jin, M. (2017). Financial Inclusion in China: Use of Credit. *Journal of Family and Economic Issues*, 38:528–540. doi:10.1007/s10834-017-9531-x.

[18] Dabla-Norris, E., Ji, Y., Townsend, R. M., & Unsal, D. F. (2020). Distinguishing Constraints on Financial Inclusion and their Impact on GDP, TFP, and the Distribution of Income. *Journal of Monetary Economics*, doi: 10.1016/j.jmoneco.2020.01.003.

[19] Decosmo, J. (2019, January 9). *How Fintechs Can Leverage Artificial Intelligence*. Retrieved from Forbes: https://www.forbes.com/sites/forbestechcouncil/2019/08/09/how-fintechs-can-leverage-artificial-intelligence/?sh=528ad84c2e1e

[20] Demirguc-Kunt, A., & Levine, R. (2008). *Finance, Financial Sector Policies, and Long-Run Growth.* Washington, D.C.: M. Spence Growth Commission Background Paper 11, World Bank.

[21] Demirguc-Kunt, A., Klapper, L., Singer, D., Ansar, S., & Hess, J. (2017). *The Global Findex Database 2017: Measuring Financial Inclusion and the Fintech Revolution.* Washington, DC. https://globalfindex.worldbank.org/sites/globalfindex/files/2018-04/2017%20Findex%20full%20report_0.pdf: The World Bank Group.

[22] Demirgüç-Kunt, A., Klapper, L., Singer, D., Ansar, S., & Hess, J. (2017). The Global Findex Database: Measuring financial inclusion and the fintech revolution. *World Bank Group*, https://globalfindex.worldbank.org/sites/globalfindex/files/2018-04/2017%20Findex%20full%20report_0.pdf.

[23] Donepudi, P. K. (2019). Automation and Machine Learning in Transforming the Financial Industry. *Asian Business Consortium*, 9 (3), 129-138. doi: 10.18034/abr.v9i3.494.

[24] Dong, J. (2018). Application Research of Artificial Intelligence Technology in Enterprise Financial Management. *International Conference on Economics, Finance, Business, and Development (ICEFBD 2018)*, doi: 10.25236/icefbd.18.056.

[25] European Commission. (2008). *Financial Services Provision and Prevention of Financial Exclusions.* Brussels: European Commission.

[26] FSB. (2017). Financial Stability Implications from FinTech. https://www.fsb.org/wp-content/uploads/R270617.pdf.

[27] Garimella, K., & Fingar, P. (2018). *AI and Blockchain.* Tampa, FL: Meghan-Kiffer Press.

[28] Goralski, M. A., & Tan, K. T. (2020). Artificial Intelligence and Sustainable Development. *The International Journal of Management Education*, 18, 100330. doi:10.1016/j.ijme.2019.100330.

[29] Hassani, H., Silva, E. S., Unger, S., TajMazinani, M., & Mac Feely, S. (2020). Artificial Intelligence (AI) or Intelligence Augmentation (IA): What Is the Future? *AI*, 1 (2),143-155. doi: 10.3390/ai1020008.

[30] Hassani, H., Silva, S. E., Unger, S., TajMazinani, M., & Stephen, M. (2020). Artificial Intelligence (AI) or Intelligence Augmentation (IA): What is the Future? *AI*, 1(2), 143-155. doi: 10.3390/ai1020008.

[31] How, M. -L., Cheah, S. -M., Khor, A. C., & Chan, Y. J. (2020). Artificial Intelligence-Enhanced Predictive Insights for Advancing Financial Inclusion: A Human-Centric AI-Thinking Approach. *Big Data and Cognitive Computing*, 4(2), 8. doi:10.3390/bdcc4020008.

[32] Hsiao, W., Lin, H., & Chang, T. (2008). Fuzzy Consensus Measure on Verbal Opinions. *Expert Systems with Applications*, 35 (3), 836-842. doi:10.1016/j.eswa.2007.07.040.

[33] Hussain, A., Wenbi, R., Xiaosong, Z., Hongyang, W., & Silva, A. L. (2016). Personal Home Healthcare System for the Cardiac Patient of Smart City Using Fuzzy Logic. *Journal of Advances in Information Technology*, 7 (1), doi: 10.12720/jait.7.1.58-64.

[34] IMF. (2021). Powering the Digital Economy. *IMF Departmental Papers*.

[35] Jahantigh, F. F. (2019). Evaluation of Healthcare Service Quality Management. *International Journal of Productivity and Quality Management*, 26 (2), doi: 10.1504/IJPQM.2019.10018913.

[36] Kim, J. Y. (2021). *Digital Financial Inclusion.* Retrieved from The World Bank: https://www.worldbank.org/en/topic/financialinclusion/publication/digital-financial-inclusion

[37] Klapper, L., & Singer, D. (2017). The Opportunities and Challenges of Digitizing Government-to-person payments. *The World Bank Research Observer*, doi:10.1093/wbro/lkx003.

[38] Kling, G., Pesqué-Cela, V., Tian, L., & Luo, D. (2020). A theory of Financial Inclusion and Income Inequality. *The European Journal of Finance*, doi: 10.1080/1351847X.2020.1792960.

[39] Koomson, I., Villano, R. A., & Hadley, D. (2020). Effect of Financial Inclusion on Poverty and Vulnerability. *Social Indicators Research*, doi: 10.1007/s11205-019-02263-0.

[40] Kshetri, N. (2019). *Global entrepreneurship: Environment and startegy (2nd ed.).* New York, NY,USA: Routledge.

[41] Kshetri, N. (2021). The Role of Artificial Intelligence in Promoting Financial Inclusion in Developing Countries. *Journal of Global Information Technology Management*, 24(1), 1-6. doi: 10.1080/1097198X.2021.1871273.

[42] Kshetri, N. (2021). The Role of Artificial Intelligence in Promoting Financial Inclusion in Developing Countries. *Journal of Global Information Technology Management*, 24(1), 1-6. doi: 10.1080/1097198X.2021.1871273.

[43] Kueski. (2021, 12 6). Retrieved from Kueski Cash 2021: https://kueski.com/?utm_source=mybusiness&utm_medium=o_org&utm_campaign=mybusiness_main_button&utm_term=ppg&utm_content=ih

[44] Kusi, B. A., Agbloyor, E. K., Gyeke-Dako, A., & Asongud, S. A. (2020). Financial Sector transparency and net interest margins: Should the private or public Sector lead financial Sector transparency? *Research in International Business and Finance*, 54. doi:10.1016/j.ribaf.2020.101260.

[45] Levine, R. (2005). Finance and Growth: Theory and Evidence. *Handbook of economic growth*, 1, 865-934. doi:10.1016/S1574-0684(05)01012-9.

[46] Mader, P. (2017). Contesting Financial Inclusion. *Development and Change*, 49(2): 461–483. doi: 10.1111/dech.12368.

[47] Mancher, M., Huff, C., Grabowski, R., & Thomas, J. (2017). *Digital Finance_The Robots are Here.* UK: Deloitte.

[48] Masood, T., & Sonntag, P. (2020). Industry 4.0: Adoption Challenges and Benefits for SMEs. *Computers in Industry*, 121 (103261), doi: 10.1016/j.compind.2020.103261.

[49] Meyer, G. G., Framling, K., & Holmstrom, J. (2009). Intelligent Products: A Survey. *Computers in Industry*, 60, 137–148. doi:10.1016/j.compind.2008.12.005.

[50] Mhlanga, D. (2020). Industry 4.0 in Finance: The Impact of Artificial Intelligence (AI) on Digital Financial Inclusion. *International Journal of Financial Studies*, 8(45), doi:10.3390/ijfs8030045.

[51] Mishkin, F. S., & Eakins, S. G. (2018). *Financial Markets and Institutions.* London, UK: Pearson.

[52] N'dri, L. M., & Kakinaka, M. (2020). Financial Inclusion, Mobile Money, and Individual Welfare: The Case of Burkina Faso. *Telecommunications Policy*, 44, doi:10.1016/j.telpol.2020.101926.

[53] Neaime, S., & Gaysset, I. (2018). Financial Inclusion and Stability in MENA: Evidence from Poverty. *Finance Research Letters*, 24, 230-237. doi: 10.1016/j.frl.2017.09.007.

[54] Novissi. (2021, December 02). Retrieved from https://novissi.gouv.tg/en/home-new-en/

[55] Omar, M. A., & Inaba, K. (2020). Does Financial Inclusion Reduce Poverty and Income Inequality in Developing Countries? A Panel Data Analysis. *Journal of Economic Structures*, 9, 37. doi: 10.1186/s40008-020-00214-4.

[56] Ongsulee, P. (2017). Artificial Intelligence, Machine Learning and Deep learning. *Fifteenth International Conference on ICT and Knowledge Engineering*, 978-1-5386-2117-2/17/$31.00 ©2017 IEEE.

[57] Ozili, P. (2018). Impact of Digital Finance on Financial Inclusion and Stability. *Borsa Istanbul Review*, 18 (4), 329-340. doi: https://doi.org/10.1016/j.bir.2017.12.003.

[58] Ozili, P. K. (2020). Financial Inclusion Research Around the World. *Forum for Social Economics*, doi:10.1080/07360932.2020.1715238.

[59] Ozili, P. K. (2020). Theories of financial inclusion. In *In Uncertainty and Challenges in Contemporary Economic Behaviour.* Emerald Publishing Limited.

[60] Ozili, P. K. (2021). Big data and artificial intelligence for financial inclusion: benefits and issues. *Artificial Intelligence Fintech, and Financial Inclusion*, doi: 10.2139/ssrn.3766097.

[61] Parsaye, K., & Chignell, M. (1993). *Intelligent Database Tools and Applicartions.* United States: John Wiley & Sons, Inc.

[62] Perez, B., & Soo, Z. (2017, October 28). *China a Fast Learner When It Comes to Artificial Intelligence-Powered Fintech, Experts Say*. Retrieved from South China Morning Post: https://www.scmp.com/tech/innovation/article/2117298/china-fast-learner-when-it-comes-artificial-intelligence-powered

[63] Rangarajan, C. (2008). *Report of the Committee on Financial Inclusion.* Government of India: Ministry of Finance.

[64] Russell, S., & Norvig, P. (1995). *Artificial Intelliegnce: A modern approach.* NJ: Prentice-Hall Englewood Cliffs.

[65] Russell, S., & Norvig, P. (2003). *Artificial Intelligence: A Modern Approach*. Englewood Cliffs: Prentice Hall.

[66] Rutherford, S. (2000). *Raising the Curtain on the "Microfinancial Services Era".* Washington, DC: CGAP Focus 15.Consultative Group to Assist the Poor (CGAP).

[67] Sahay, R. (2015). *Financial Inclusion: Can it Meet Multiple Macroeconomic Goals? (No. 15/17).* Washington: International Monetary Fund.

[68] Sarma, M. (2008). Index of financial inclusion. *Working Paper No. 215, Indian Council for Research on International Economic Relations (ICRIER)*.

[69] Schuetz, S., & Venkatesh, V. (2019). Blockchain, adoption, and financial inclusion in India: Research opportunities. *International Journal of Information Management*, doi: 10.1016/j.ijinfomgt.2019.04.009.

[70] Schuetz, S., & Venkatesh, V. (2019). Blockchain, Adoption, and Financial Inclusion in India: Research opportunities. *International Journal of Information Management*, doi:10.1016/j.ijinfomgt.2019.04.009.

[71] Senyo, P., & Osabutey, E. L. (2020). Unearthing Antecedents to Financial Inclusion through FinTech Innovations. *Technovation*, doi: 10.1016/j.technovation.2020.102155.

[72] Sharma, G. D., Yadav, A., & Chopra, R. (2020). Artificial Intelligence and Effective Governance: A Review, Critique and Research Agenda. *Sustainable Futures*, doi: 10.1016/j.sftr.2019.100004.

[73] Shi, Z. (2009). Intelligence Science. *International Workshop on Rough Sets, Fuzzy Sets, Data Mining, and Granular-Soft Computing* (pp. 20-32.). Heidelberg: Springer, Berlin.

[74] Svirydzenka, K. (2016). Introducing a New Broad-based Index of Financial Development. *IMF Working Paper*, WP/16/5.

[75] Tchamyou, V. S. (2019). The Role of Information Sharing in Modulating the Effect of Financial Access on Inequality. *Journal of African Business*, doi: 10.1080/15228916.2019.1584262.

[76] Tchamyou, V. S., & Asongua, S. A. (2016). Information Sharing and Financial Sector Development in Africa. *Journal of African Business*, doi: 10.1080/15228916.2016.1216233.

[77] Triki, T., & Faye, I. (2013). *Financial Inclusion in Africa.* Tunis: African Development Bank.

[78] Truby , J., Brown, R., & Dahdal, A. (2020). Banking on AI: Mandating a Proactive Approach to AI Regulation in the Financial Sector. *Law and Financial Markets Review*, 14 (2), 110-120, doi: 10.1080/17521440.2020.1760454.

[79] Tulasi, G., Golait, R., & Goe, S. (2017). Involuntary Exclusion and the Formal financial sector. *Economic and Political Weekly*, 52(36), 67-72.

[80] UNDP. (2016). Human Development Report 2016: Human Development for Everyone. *Global Human Development Reports*, http://hdr.undp.org/sites/default/files/2016_human_development_report.pdf.

[81] United Nations. (2016). *Digital Financial Inclusion. International Telecommunication Union (ITU), Issue brief series, Inter-agency Task Force on Fancing, July. United Nations.* Available at: http://www.un.org/esa/ffd/wp-content/uploads/2016/01/Digital-Financial-Inclusion_ITU_IATF-Issue-Brief.pdf.

[82] United Nations. (2016). *Human Development for Everyone.* New York: United Nations Development Programme.

[83] UNSGSA. (2021). *The Imperative of Financial Inclusion.* Retrieved from United Nations Secretary-General's Special Advocate For Inclusive Finance For Development: https://www.unsgsa.org/financial-inclusion

[84] Vaio, A. D., Palladino, R., Hassan, R., & Escobar, O. (2020). Artificial Intelligence and Business Models in the Sustainable Development Goals Perspective: A Systematic Literature Review. *Journal of Business Research*, 121, 283-314. doi: 10.1016/j.jbusres.2020.08.019.

[85] Van, L. T.-H., Vo, A. T., Nguyen, N. T., & Vo, D. H. (2019). Financial Inclusion and Economic Growth: An international evidence. *Emerging Markets Finance and Trade*, doi: 10.1080/1540496X.2019.1697672.

[86] Vinuesa, R. (2020). The Role of Artificial Intelligence in Achieving the Sustainable Development Goals. *Nature Communications*, 11, 233. doi:10.1038/s41467-019-14108-y.

[87] Vo, D. H., Nguyen, N. T., & Van, L. T. (2021). Financial Inclusion and Stability in the Asian Region Using Bank-Level Data. *Borsa Istanbul Review*, 21 (1). 36-48. doi: 10.1016/j.bir.2020.06.003.

[88] Vo, D., Nguyen, N. T., & Van, L. T. (2021). Financial inclusion and stability in the Asian region using bank-level data. *Borsa Istanbul Review*, 21 (1), 26-43. doi:10.1016/j.bir.2020.06.003.

[89] Wall, L. D. (2018). Some Financial Regulatory Implications of Artificial Intelligence. *Journal of Economics and Business*, doi:10.1016/j.jeconbus.2018.05.003.

[90] Wayne , T., Soetan, T., Bajepade, G., & Mogaji, E. (2020). Technologies for Financial Inclusion in Nigeria. *Research Agenda Working Papers*, 4, 40-56. https://ssrn.com/abstract=3562890.

[91] World Bank. (2014). *Global Financial Development Report 2014 : Financial Inclusion.* Washington DC: The World Bank.

[92] WSSD. (2002). World Summit of Sustainable Development . *Plan of implementation of the world Summit on sustainable development.*, https://www.un.org./esa/sustdev/documents/WSSD_POI_PD/English/WSSD_PlanImpl.pdf.

[93] Yaroslava, B., Maya, G., & Davit, K. (2018). *Financial Inclusion, Fiancial Literacy, and Financial Education in Georgia.* Tokyo: ADBI Working Paper, No. 849, Asian Development Bank Institute (ADBI).

[94] Yen, J., & Lengari, R. (1998). *Fuzzy Logic: Intelligence, Control, and Information.* New Jersey: Prentice Hall.

[95] Zadeh, L. A. (1965). Fuzzy Sets. *Information and Control*, 8, 338-353.

[96] Zetzsche, D. A., Arner, D., Buckley, R., & Tang, B. W. (2020). Artificial Intelligence in Finance: Putting the Human in the Loop. *Centre for finance, Technology and Entrepreneurship* , https://ssrn.com/abstract=3531711.