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Artificial Intelligence and Bank Soundness: A Done Deal? - Part 1

Charmelee Ayadurai and Sina Joneidy

Abstract

Bank soundness plays a crucial role in determining economic prosperity. As such, banks are under intense scrutiny to make wise decisions that enhances bank stability. Artificial Intelligence (AI) plays a significant role in changing the way banks operate and service their customers. Banks are becoming more modern and relevant in people's life as a result. The most significant contribution of AI is it provides a lifeline for bank's survival. The chapter provides a taxonomy of bank soundness in the face of AI through the lens of CAMELS where C (Capital), A (Asset), M (Management), E (Earnings), L (Liquidity), S (Sensitivity). The taxonomy partitions opportunities from the main strand of CAMELS into distinct categories of 1 (C), 6 (A), 17 (M), 16 (E), 3 (L), 6 (S). It is highly evident that banks will soon extinct if they do not embed AI into their operations. As such, AI is a done deal for banks. Yet will AI contribute to bank soundness remains to be seen.

Keywords: bank, bank soundness, financial sector, Artificial Intelligence (AI), CAMELS

1. Introduction

The Global Financial Crisis (GFC) showcased that banks driven solely by profit, earnings and share price maximisation alone would fail. Although, success or failure of banks is highly dependent on the bank's ability to make money, it is not the only determinant of bank soundness. Amongst the equally important success factors lies in adequate capital and liquidity holdings, quality assets and making sound management decisions, that leads to the creation of value. As such, Capital (C), Asset (A), Management (M), Earning (E), Liquidity (L) and Sensitivity (S) (CAMELS) are important determinants of bank's health and wellbeing [1–3].

Artificial Intelligence (AI) is expected to deliver additional global economic output of \$13 trillion a year [4], contribute \$15.7 trillion to the global economy by 2030 [5] and is expected to increase productivity gains by 20–40% [6]. Several initiatives have emerged as a result where approximately \$1 trillion in

costs is expected to be exposed to AI transformation in financial services sectors by 2030, out of which \$450 million of this is in banking [6]. While, European Commission has increased its annual investments in AI by 70%. AI market is expected to be worth \$16.06 billion by 2022, growing at 62.9% compound annual growth rate [7].

The numerous efforts and initiatives in AI investment suggests that AI is here, and it is here to stay. As such, the chapter looks to critically assess how able are banks to effectively deploy AI into their daily operations to improve CAMELS from a bank's perspective.

The chapter contributes to literature in several ways. Early research has emphasised on the application of AI on the financial sector as a whole [6, 8, 9] or comparative analysis of AI applications in specific areas as service providers such as credit evaluation, portfolio management, financial prediction and planning [10–13] or by examining customer experiences [5, 6, 8]. Therefore, these studies are not sufficient to understand the opportunities proposed by AI from a bank's sole operational perspective. To fill this gap the chapter has taken a holistic approach in scrutinising the opportunities relished by solely deploying AI in banks. By doing this the chapter provides a significant insight into the important opportunities that AI technology can offer the banking industry to ensure its survival.

The chapter also further considers bank soundness with the application of AI from various aspects of Capital (C), Asset (A), Management (M), Earning (E), Liquidity (L) and Sensitivity (S) (CAMELS) as determinants of bank soundness. To the best of our knowledge, this chapter is the first reviewing deployment of AI in banking operation in light of CAMELS. Earlier research [1–3] has only emphasised on bank soundness from the CAMELS perspective.

The chapter also more specifically focuses from both the service provider and customer end, providing further insight from a holistic perspective. Most importantly, the intention is to examine through the lens of CAMELS how sound are banks having applied AI into their processes.

The chapter is organised as follows: the next section presents a brief theoretical discussion on the importance of embracing AI for banks. Section three introduces research method. Section four presents result and discussions on the opportunities relished by banks on application of AI from CAMELS perspective. The last section concludes the chapter and highlights insight on further research.

2. Literature review

Banks are the heartbeat of an economy. Yet, despite central banks efforts to keep banks afloat through recapitalization and cash injections banks are still underperforming, failing, with one or two microfinance banks disappearing annually [14]. On top of this, the Global Financial Crisis (GFC) has caused many more bank failures leading to concentration in the financial markets. To promote economic growth governments lowered entry barriers to encourage more players to enter and stimulate competition in the financial markets. In UK, new banks could enter the market with reduced capital and liquidity requirements [8]. This led to the growth of Fintech, technology-based companies that offer financial products at competitive rates. Challenger banks whose competitive advantage lies in its digital

technology build on Machine Learning (ML) outperformed UK's five big banks through fierce competition and subsector domination in the field [8, 15].

Studies have confirmed that the sluggishness and weaknesses in the banking industry rest in the banks' inability to tap into AI solutions. Thus, the biggest game-changer for banks lies in its rapid adoption of AI technology. AI is a competitive advantage for banks. As it not only helps banks to remain competitive, but also to fight off weak profitability [5, 16–18]. As such, AI is no more an enabler or enhancer of productivity but a necessity that ensures bank survival and sustainability.

The incoming and future customers of banks are Millennials and Generation Z. These generations are more in tuned to technology-based services, and thus, demand more choices, flexibility, and control over banking. As such, banks need to embed AI into their operations to cater for the twenty first century customers' expectations offering a wide range of services, in seconds, twenty-four hours, seven days a week.

Banks also work with large volumes of data. As such, it is inhumanly impossible to process, find patterns, make fast and accurate decisions in a timely manner. AI on the other hand, is capable and has the capacity to conduct the job effortlessly in real time with increased data storage at a lower cost. The constant advancement in AI technology also enhances AI capabilities and capacities making it limitless [9] enabling banks to offer extraordinary services to its customers.

The GFC and the opaqueness of the banking industry has led to increased scrutiny and regulation on banks. This makes digital platforms a necessity. Digital platforms ensure all data are consistently and systematically recorded in a logical and meaningful manner, making processes more transparent, increasing the reliability and confidence in the banking system [5, 12].

It is apparent that banks cannot exist without the help of AI in moving forward.

3. Research methods

The research is conducted as a conceptual chapter with the aim to provide a deeper understanding of the opportunities parted by AI from a service provider and customer perspective. To answer the research question on how able banks are to effectively deploy AI into their daily operations to improve CAMELS from a bank's perspective, a systematic review of the literature and objective observations were undertaken to examine banks through the lens of bank soundness determinants of CAMELS. The observations found in existing literature are gathered to assemble a framework categorized by CAMELS in **Figure 1**. The literature was gathered through the Scopus database. The database offers a wide range of management and business-related studies relevant for the topic of research. In addition, other databases such as Google Scholar, Social Science Research Network (SSRN), SpringerLink and IEEE Xplore were also examined. Journal articles since the period 2000–2020 were extracted using the prescribed keywords of Bank, Bank soundness, Financial Sector, Artificial Intelligence (AI), CAMELS. Only articles that were available in full text, published in scholarly, peer reviewed journal were chosen to be closely examined. The search was also conducted using the backward and forward approach where reference list of articles was utilised to find further research papers.

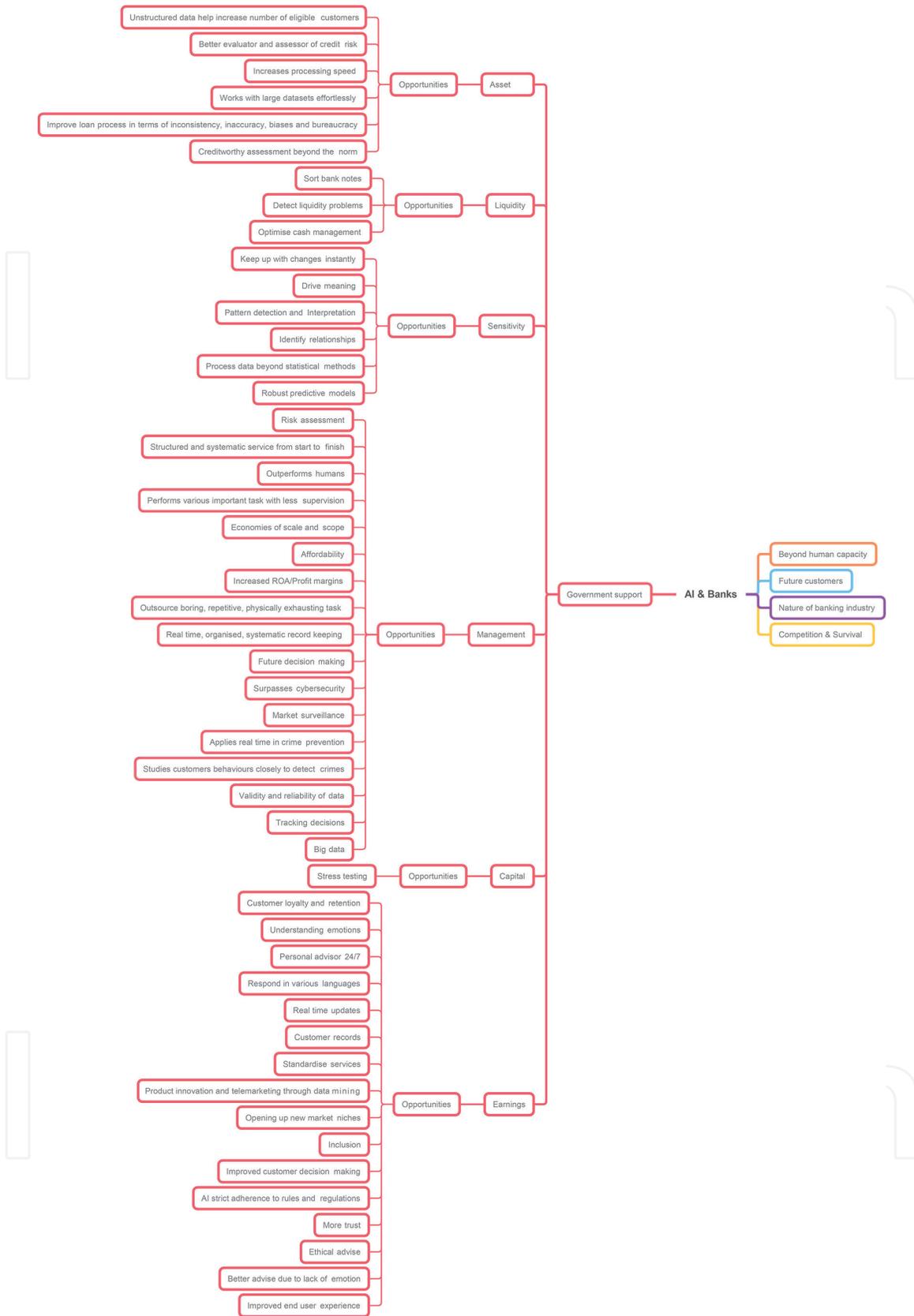


Figure 1. Taxonomy of opportunities posed by AI on Bank Soundness - a classification based on the determinants of Bank Soundness through the lens of CAMELS.

4. Findings and discussion

This section presents an overview of the opportunities relished by banks in deploying AI in their daily back-office operations to customer services prescribed from the CAMELS perspective (see **Table 1** in the Appendix).

4.1 Capital

Bank capital acts as a core determinant for bank's survival. Capital absorbs losses during adversity and insufficient capital holdings can cause banks to collapse. AI with its limitless abilities and capabilities helps banks to hold robust capital holdings through stress testing.

Basel requires banks to demonstrate their ability to remain adequately capitalised especially during dips in the economy, stressful scenarios and most importantly during crisis. As AI works with big data, real time and real-world scenarios, it is able to help banks immensely with detail capital-planning processes to ensure its robustness. Citigroup successfully applies ML techniques to model Comprehensive Capital Analysis and Review (CCAR), thus, meeting its stress testing requirements [19–21]. ML algorithms could also project CCAR losses [21].

4.2 Asset

Asset quality is measured by the level of credit risk contained in bank's assets [22]. Therefore, a bank that can detect, measure, monitor and regulate credit risks will hold higher quality assets [23]. The GFC showcased that credit risk is the most challenging risk to manage and control as it not only absorbs profits but exposes banks to failures as well. AI helps banks to clearly assess and evaluate customers' risk, eliminating ambiguity and biasness while improving loan processes.

As most finance related data are text heavy it can be a challenge to track data systematically and consistently. Intelligent Trading Systems screen both structured (databases, spreadsheets, etc.), unstructured (social media, news, etc.) data [12] and apply ML with improved analytics and data modelling [24, 25] to offer meaningful insights on the ability of customers to pay back their loan undertakings. Studies have also confirmed that the use of unstructured data can boost the number of eligible loans [9].

Banks apply credit scoring to issue loans and to make investment and risk management decisions. As credit risk is evaluated through credit scoring, the accuracy of credit scoring is necessary for bank's earning as even a 1% improvement in the accuracy of prediction could lead to significant decrease in losses to financial institutions [26]. As AI supersedes traditional statistical scoring models with its ability to work with big data and nonlinear relationships, AI improves the accuracy of prediction [26, 27]. Thus, a better evaluator and predictor of credit risk, reducing significant losses from non-performing loans [26, 28–30]. ML measures credit risk, detect patterns in data, identifying and notifying banks on good and bad borrowers, [30, 31] detect high risk loan applicants [32], identify customers that are being over or under charged for credit risk paying higher or lower credit risk premiums to gain market share or reduce losses. These customers can be offered lower price loans or denied loan request [15]. AI applies logical deduction to differentiate between high default risk applicants and credit applicants who are credit-worthy but do not have a comprehensive credit history [12].

Advance machine learning algorithms with increased number of transistors, computing and processing power with improved speed of central processing units has enabled algorithms to analyse data and process information much faster, improve processes, enable faster loan origination, and contributes to the accuracy in decision making [9, 17, 25]. Besides, Robo-advisers and online broker community combined efforts have helped to further expediate credit checks and loan evaluation processes [8]. JP Morgan Chase uses Contract Intelligence (COIN) to interpret commercial-loan agreement faster as it takes lawyers and loan officers 360 000 hours each year [15, 33] and is also able to extract 150 relevant attributes from

commercial loan agreements quickly [21]. Bank of America and Merrill Lynch apply ML through Intelligent Receivables Solution to improve reconciliation of incoming payments that help post its receivables faster [21].

Credit scoring is evaluated based on 5Cs: the character of the consumer, capital held, collateral offered, the capacity of the customer and the economic conditions. However, the rise in number of applicants, makes it impossible to conduct the work manually for each and every customer [26]. AI in the form of ML not only can perform challenging tasks such as sifting through floods of data from repayment history to collaterals, but also simultaneously understand processes, discover useful patterns or relationships, extract valuable information and analyse large volumes of information from large datasets, making the right loan decisions based on customer's affordability, at record speeds, accurately, in a fair and objective manner [8, 9, 13, 15, 30]. Thus, improving quantity and quality of loan approvals.

Manual underwriting task requires full attention to detail, sound judgement from each and every department to produce a quality outcome. Loan officers rely on their own experiences, experiential knowledge, intuition, checklists of bank rules and conventional statistical methods to evaluate loan applications. Yet, loan officers are humans tied to relatives and friends and are subject to emotions. As loan decisions are subjective, loan judgements can be inconsistent, inaccurate, or bias. For example, a loan officer who is absolute that the results will hold a linear relationship or assumes an incorrect functional form [30]. AI can train with new examples and learn from past experience to provide better outputs, reducing subjectivity [30] and biasness in decision making. Robo-advisers and online broker community combined efforts have also known to have shortened bureaucratic processes [8]. As such, AI can improve decision making processes to enhance the outcome [30, 34]. However, in exceptional circumstances, it is important to include a human in the loop [30, 34]. In summary, AI helps banks to be more efficient, effective, effectual, and efficacious in their operations, delivering world class services to customers.

The introduction of AI has allowed banks to analyse customer's loan repayment ability beyond traditional evaluation techniques of ratios, credit history and credit scores [8]. AI tracks customer spending habits through shopping patterns, social media activities, internet searches, customer's holidays, hobbies, interests, job related searches, connections, social activities, location consistency, network diversity amongst others [8]. This approach is particularly useful for customers with insufficient credit records. The new approach has successfully garnered 90% repayment rate [8].

4.3 Management

Banks rely heavily on management to not only generate earnings and increase profit margins [2] but also to keep banks alive [35].

AI is used in risk management to design algorithms that analyse the history of risk cases and identify early signs of potential future issues [12, 36]. AI applies structured and systematic approach in making decisions by ensuring that customers have enough understanding of investments and the mechanisms of the financial markets in general before learning about the customer's circumstances namely number of dependencies, type of profession, assets, and liabilities etc. Then questions related to investment, namely target return and risk levels is asked to determine the optimal risk–return level of the investment portfolio. The customer's response is then checked against the application to detect inconsistencies and gaps are filled by asking customers to provide further explanations where and when is necessary to classify customers into different categories based on their risk–return profile and finally prescribe the right investment fund best suited for the customer.

AI then provides after care service of continuous management of the portfolio while constantly touching base with the customer on the market changes and variations of asset features and its effects on the customer's financial position [12, 37]. This keeps customers up to date about their finances from start to finish.

AI takes longer to learn than humans, but it is constantly learning from its previous decisions to improve accuracy and performance overtime. In the long run, AI outperforms humans proving to be more effective and efficient. AI is consistent, does not easily get distracted, able to multi-task as machines can think faster, operates with higher degree of precision and accuracy, programmed to work for long hours providing non-stop services i.e., automated teller machine (ATMs) that replaces the working hours of bank clerk and an auto call centre that can pick up calls at any time [8, 12, 15, 17, 37, 38]. Studies show that only 25% of human fund managers can outperform the market. Fund managers need to constantly keep up with unpredictable markets, constant flux in regulations, customers' wants, amongst other factors that influences decision making process [8]. AI works with real time data thus, can instantly use up-to-date information of all market activities when deciding on an investment advice [12].

AI is self-taught. It acquires knowledge through observation and analysis, draw conclusions and take appropriate actions autonomously. AI can also perform various task with little human supervision, namely document reading through natural language where processing is used to interpret written inputs, such as research documents, news, stories and social media content to create analysis that can be used to identify investment opportunities while simultaneously considering human behaviour [12, 37, 39], apply machine learning to automate data preparation and is able to analyse complex task to develop insight [17, 25, 40]. AI is said to be revolutionising the investment industry through the application of quantitative optimisation. Where no human intervention is needed in managing customer's portfolios [12].

Although AI requires high initial investment but when the cost of developing the system has been met, the marginal cost hereon related to each new transaction is relatively low [41]. Further advancement in the field of AI have lowered the marginal cost of acquiring, managing and analysing data further [8, 15, 26, 42]. As a result, the service provider benefits from economies of scale. As more customers adopt the service, unit cost per transaction reduces considerably [15]. For example, services that require little management such as Exchange Traded Fund (ETF)s [37] have reduced management, personnel, and asset costs. The reduced price enables banks to serve a bigger customer group with a wider scale of market segment, expanding its scope globally while creating steady revenue streams [12, 37].

On top of that, AI can perform excruciating, repetitive task, and work for long hours without having to pay out high remunerations [8]. AI is also successfully integrated in financial institutions because of its affordability. Combined reduction in cost of data storage, cost of hard drive per gigabyte, data identification tools such as machine learning complete with big data input has led to the success of AI [17].

Studies have shown a positive and strong correlation between higher number of AI patents registration and bank profits [17]. There are no qualms that AI has significantly increased labour productivity as this is evident in European banks with pronounced return on assets and reduced cost, combating the persistent weak profits experienced by banks prior to AI adoption [17].

AI not only perform tasks which is difficult and impossible, but it also carries out tasks that no one enjoys, repetitive which are monotonous in nature, costly, laborious, low added-value (e.g., replies to Frequently Asked Question (FAQ)s). Thus, reducing human error, boosting productivity, and cutting the cost of these tasks [9, 15, 17, 38].

First National Bank of Wynne in Arkansas uses AI to migrate customer account information to the acquiring bank's core system. AI possesses all the necessary skills

to complete the task from its ability to learn fast, perform repetitive task quickly without mistakes, report errors, validate data, to complete the task on time and effortlessly. The bank saved 70% in conversion costs.

Banks outsource repetitive task such as mass reissue of debit cards due to a breach [6], data entry, filling out forms to answer what if questions. This helps banks to reduce the demand for less-skilled labour and helps existing workers to focus on more interesting and creative tasks. 67% of non-executive bank employees believe that AI will improve their work-life balance while 57% expect it to expand their career prospects [6]. AI Debt-collectors handle loan collection work for most banks. As AI lacks emotion, AI can handle abusive behaviour without providing an emotional response such as getting upset, angry or misbehave, avoiding tense situations [6]. Customers can let off steam and yet not jeopardise their relationship, paying up subsequently with a patient and understanding AI.

AI ensures all information especially legal documents and requirements of collecting, processing, utilising, and categorising information is done in a systematic way and documented correctly, making it more efficient than human advisors [12, 37]. The automatic, real-time record keeping ensures proper record keeping, improves transparency compared to traditional processes that are highly administrative, bureaucratic, require repetitive data entries and unnecessary paperwork [14, 17]. AI automated recorded processes helps to easily track reasons behind each decision made. AI provides consistent recommendations in a systematic, structured, and logical manner. Enabling easy understanding of the decisions made. AI is connected to cloud. It can learn new things constantly, update itself and store information cheaply in cloud for future analysis. Research predicts that increase adoption of AI in banks will allow large volumes of data to be preserved for data-driven decision making in the future [17].

Strong growth in online and mobile payments coupled with an increase in cyber-attacks has forced banks to adopt AI. An increase in number, speed and complexity of the dynamic cyber-attacks carried out by intelligent agents such as computer worms and viruses show that conventional fixed algorithms are futile and only an intelligent semi-autonomous agent (such as Computational Intelligence, Neural Networks, Intelligent Agents, Artificial Immune Systems, Machine Learning, Data Mining, Pattern Recognition, Fuzzy Logic, Heuristics, etc.) is capable enough to detect, analyse, evaluate the entire process of attack before providing an appropriate respond in a timely manner to defuse the attack as well as prioritising and preventing secondary attacks [43]. On top of that, AI surpasses cybersecurity with its extraordinary safety features and abilities. While cybersecurity helps to reduce the number of successful attacks on the system, AI wipes out attacks completely to zero [44]. AI in the form of ML techniques works with real-time in checking the credibility of credit card transactions before comparing new transactions with previous amounts and locations. Transactions that pose a risk are blocked immediately by AI. Studies have confirmed AI's accuracy in these processes and its capability to protect customer security [9, 17, 45].

UK banks namely Santander, Barclays, RBS, and HSBC use voice recognitions for telephone-based customer services [8]. Studies have confirmed that banks have to introduce AI into their operations from the start at data input level to detect human involvement in cybercrimes, fraud, money laundering etc. AI being present at every stage of the process enables it to critically evaluate the data given, find unusual behaviour patterns outside a person's behavioural norm triggering alerts. AI with the aid of big data is able to analyse and filter large volume of customer transactions for anomalies, patterns or a series of scenarios including money laundering, illicit transactions, cybercrimes [46] and security threats faster, with

more accuracy [8, 9] that would otherwise have gone unnoticed with lower number of false positives [38].

Global banks bear more than \$230 billion in misconduct costs [47]. As such, ML helps to closely monitor traders' behaviour from trading patterns, email traffic, calendar items and telephone calls [45]. The U.S. Securities and Exchange Commission applies ML to extract actionable insights to better regulate market activities, facilitate automated security registration processes, and assess corporate risk. AI works based on "know your customers" processes. As such, AI algorithms can scan client's documents to check the validity and reliability of the information provided by comparing it with information from different databases. If AI algorithms identify inconsistencies, it raises a red flag and a more detailed check by bank employees is performed [17].

Banks have the upper hand in large datasets [15] to make better decisions with higher accuracy.

4.4 Earnings

Banks that manage their expenses well while fully utilising their assets to generate constant revenue streams are most likely to be sound [2]. AI enables banks to offer unique selling points in products that increases customer satisfaction, boosting sales and revenue [8].

As customers in banks grow, opting for various services offered, with different periods of maturity it is difficult for banks to keep a close eye or to personally service each and every customer. On average banks handle five million transactions per day, five million individual accounts, over three million customers with hundreds of product types. As such, most customers feel disconnected from their otherwise committed bank. Banks are starting to realise that reconnecting and rebuilding this relationship is essential not only to retain customers but most importantly to gather information about customers' preferences to provide satisfactory product and services, garnering their loyalty [48].

AI also can detect movement and understand human emotions while responding with simulations of emotions like joy, anger, and irritation [38]. AI is an invisible virtual personal financial advisor that attends to individual customer's need twenty-four hours, seven days a week [8, 9, 12, 38]. Banks can offer unique, extraordinary, and personalised digital experiences with personalised products and services to their customers as a result [5, 8]. As AI monitors each and every customer's account individually, AI sends instant alerts on spending, account balance and budget alerts if geolocalisation services detect that customers are shopping. AI is also quick to act i.e., providing advice to stop customers from getting into further debt if it predicts that customers will get into financial troubles. AI is also on standby to offer advice on credit cards, ETFs, stocks, bonds, fixed deposit, current account, personal loan, retirement planning, mortgage, ISAs (Individual Savings Account), insurance cover if the customer is buying a house, car or electrical household item [8, 12, 49]. Algorithms can also develop personalised portfolios based on individual customer's asset and liabilities, risk and return trade off and investment capabilities [12, 50].

Bank of America, Capital One, Société Générale, Swedbank, Royal bank of Canada together with big five Canadian banks, Danske Bank and Nordea bank in Nordic countries, Hong Leong Bank, RHB and CIMB in fast east Malaysia, Mitsubishi UFJ Financial Group Inc. and Mizuho bank in Japan are all active users of AI chat-bots [6, 8, 38]. The most sophisticated Robo-advisory service originates from United States, United Kingdom and Germany [51].

Chatbots, virtual assistants and Robo-advisors offer automated communication channels to customers in the form of personal financial advisory services. Provide a wider range of services, which includes answering simple and repetitive questions, handling lost or stolen bank cards, re-setting PIN numbers, perform transactions such as order transfers, open accounts, paying bills, reload prepaid phones, checking account balance, interacting with customers, guide customers through disclosure and compliance questions more carefully than humans, collect data on customer preferences and interests to offer relevant, tailored and personalised products to customers, enable users to settle common doubts, secure product recommendations, schedule appointments via phone according to the customer's preferred date and time, process mortgage applications and insurance claims such as opportunity and risk alerts, push notifications for market updates, periodic portfolio reviews, alert customers within twenty four hours via SMS (Short Message Service) on loan approvals, guides and supports customers from start to finish through automated financial advisory processes, empowers customers to independently make more informed consumption, saving, personal finance and wealth management decisions.

In other words, AI has enabled customers to access, receive guidance and advise, adjust their portfolios anytime of the day to recalibrate their investments, empowering customers [8, 9, 12, 17, 37, 38, 52, 53]. Besides, Robo-advisers and online broker community combined efforts have enabled loan officers to provide a more detail guidance to each and every customer based on their individual circumstances [8].

Chatbots can interpret and respond in various languages. Thus, can resolve customers' routine questions saving human advisors' time, increase efficiency and effectiveness of the service provided to customers, increasing client base [12, 39]. AI works with real-time information and therefore informs and updates itself with the most up to date information and news from connected networks before revising customers finances to alert and advise them accordingly [12, 17, 37].

AI automatically records every conversation, interactions and information provided by customers. The automatic, real-time records cover historical records to recent transactions made and advise given. The structured and organized records are useful when handling customer complaints and helpful to decision makers to make fast, prompt, and accurate decisions [12].

AI's automated processes offers a standard service to all customers, ensuring customers are treated similarly, fairly, and equally eliminating biasness [12, 37]. More than 70% of financial institutions in North America agree that big data offers them a competitive advantage over their competitors and 90% believe big data is the determining success factor for banks [17]. Large global banks are turning to data mining for insight on customers' preferences and choosing telemarketing clients to remain competitive in the digital world [17, 54]. Big data coupled with great analytical capacity of AI allows banks to track customer's spending habits, preferences, developing tailor-made products and services, and even anticipate customers' needs while improving user experience. Chatbots' interactions are also collated to customise end products and services [9]. As a result, new, innovative, and tailor-made products and services are developed that are useful, helpful, and better suited to client preferences in the future [17].

World Economic Forum's White Paper estimates that the global retirement savings gap, caused by longevity and insufficient savings, is projected to balloon to \$400 trillion by 2050 in countries with the largest pension markets or biggest populations namely Australia, Canada, China, India, Japan, Netherlands, UK, and USA. Studies agree that AI can open a new niche for banks to explore by offering simple, cheap, and non-judgemental financial advice [8]. The emergence of AI has

created new set of Robo-advisors designed to follow a low budget structure [37] creating a new niche for low-budget investor class [37].

Studies have also confirmed that banks are in a strong position to venture into real estate business by adopting a virtual real-estate agent powered by AI. AI algorithms coupled with customer house preference information will narrow down searches on viable housing options to the customer. This will provide transparency of the house buying process to customers, improve customers' house buying experiences, increase customer satisfaction, reduce customer churn and banks' operational costs while maintaining its profits margins through mortgage loans and increase revenues from adjacent areas of sales such as insurance, personal loan, etc. [5].

The adoption of AI is allowing banks to offer wider range of services to a larger number of customers at affordable prices. Therefore, all customers are granted the same access to all financial services that might have otherwise been excluded (e.g., lending to customers with whom a bank had no previous relationship with or personalised financial advice services) promoting inclusion [9].

Lack of financial knowledge and overconfidence has led customers away from human advisors [55]. In Finland, approximately 76.6 billion euro are left in personal current accounts earning virtually no interest [12]. AIs are more open than humans offering a safe platform for customers to realistically understand their level of financial knowledge without the fear, discomfort, and embarrassment of sharing their vulnerability with human advisors [12]. In this sense, Robo-advisors have helped customers who previously did not have any investments or savings before to increase their investment [12].

The GFC showcased the greediness, recklessness, and dishonesty of human decision makers in globally reputed banks namely RBS, Barclays, HBOS amongst others [8]. AI's absence of self-interest ensures rules, processes as well as procedures are strictly adhered to [8].

As AI does not work with an agenda i.e., to be promoted or self-interest, AI offers more neutral advice to customers. As a result, customers have more trust in Chatbots than human advisors [8, 12]. Customers feel comfortable to open and disclose spending habits or retirement savings to AIs for its lack of judgement on customer's spending habits and retirement savings. 68% customers Robo-advice in retirement planning [8].

As human advisors are attached to their own personal agenda and interest, their advice can be biased. They might suggest products that gives them the highest incentive or commission and not necessarily helpful to the customers. In this sense, AI is ethical and product-neutral and offers advise with zero conflict of interest [12, 55]. Besides, AI is also more transparent in revealing all the costs customers are subjected to pay and keeps customers in the loop by alerting customers when new fees are charged [12, 56].

Human decisions can be influenced and driven by emotions, cognitive biases, such as overconfidence, and limited cognitive abilities [55, 57], irrationality [58]. However, Robo-advisors have proven to make better decisions due to lack of emotion, strict adherence to rules, following a systemic decision-making process [8, 12, 59].

AI with the combined efforts of big data and ML (BD/ML) enables speedy, flexible, tailored, cost effective (as it charges reduced fee by a fraction compared to human advisors), convenient, creating wider range of services, making all services available to a broader range of users, as well as offering better services, heightening efficiency, enhancing quality, creating happy customers with raised customer satisfaction levels [8, 9, 21, 60, 61]. Robo-advisory systems simplifies customers' user experience [12, 37], translate user interface into the language of the customer's

choice by welcoming customers in customer's preferred language while explaining products and services in the preferred language of choice [12].

4.5 Liquidity

Banks must hold sufficient liquidity funding to meet unforeseen deposit outflows. Banks that struggle to meet its daily liquidity needs will eventually fail [2]. Central banks working on larger scales overseeing the workings of the market use AI to sort large number of bank notes and detect liquidity problems.

Central bank of Netherlands applies AI to detect potential liquidity problems in financial institutions [9]. In Banco de España, AI has been deployed to sort fit and unfit banknotes for circulation [9].

ATMs are the most important cash distribution channels for banks. Yet, banks face a constant challenge to hold sufficient supply of currency to meet consumer's demand causing lost surcharge fees and increased expenses from emergency currency deliveries as overstocking currency would mean a reduced investment for banks. ATMs must work closely with the dynamic and constantly changing environment to derive greater efficiency in cash management. As such, to optimise cash management and to achieve efficient cash loads routing forecasting algorithms capture and process historical data to gain insight into the future. The demand for cash lies more on the days i.e., holidays, weekends, starting of month, festival days etc. than time itself. As such, Hybrid Back Propagation/Genetic Algorithm approach has proven to optimise cash management of ATMs on real time with more accuracy compared to traditional ATMs.

4.6 Sensitivity

Banks are subject to market risks (i.e., interest rate risk, foreign exchange risk, price risk etc) that can have adverse effects on bank's earnings and capital. AI provides solutions to real world problems [30], through real-time, enabling banks to keep up, adapt and respond to constant and dynamic changes in the environment. Improving bank stability and soundness.

The constant influx in business environments, banking credit and regulatory standards, bank lending strategies, marketing strategies of banks, investor requirements, customer demands and borrowing patterns of customers require frequent revisions [30, 60]. ML systems not only can execute rules and keep up with change in processes, but it is also able to process this information in milliseconds [13] as it works with real-time.

Neural networks identify interconnected nodes through multi-layered data from multiple disciplines, such as statistics, computer science, biology, psychology, economics i.e., game theory, and applies multitude techniques to derive meaning [40].

ML applies algorithms to sift through hundreds of thousands of factors to proficiently detect [30, 62], decode patterns and linkages in the data by continuously updating "learning" [40]. Pattern recognition uses tools such as natural language processing to classify and interpret data [40].

ML uncovers relationships beyond causal i.e., relationships that is yet to be established by theory. Supervised ML also understands non-linear relationships while unsupervised ML reveals commonalities amongst different groups whilst highlighting outliers. ML not only unravels hidden relationships but also provides additional information about the dataset which can be further used by banks and financial supervisors alike to understand the workings of the financial markets and institutions better [15, 21].

AI algorithms work with soft-computing approaches beyond parametric statistical methods (e.g., discriminant analysis and logistic regression) and nonparametric statistical methods (e.g., k nearest neighbour and decision trees) [10]. AI also works with variables that give contradicting signs, model noisy, inconsistent, or incomplete data [63, 64], identify both linear and non-linear relationships [30], work more closely with real world non-linear applications and can handle uncertain behaviours that changes over time [10]. AI's accuracy surpasses traditional statistical models and is a crucial tool in decision making processes.

Advancement in AI methodologies have also enhanced the robustness of predictive models, and thus, its outcomes. As such enabling users to predict future outcomes and make decisions more effectively [62], efficiently and more accurately.

5. Conclusion

In this chapter we were keen to explore how able are banks to effectively deploy AI into their daily operations to improve CAMELS from a bank's perspective. It has become apparent that AI contribution is limitless, and its uses are infinite [65–67], offering significant possibilities for banks to survive. Government are in joint agreement that AI will not only help banks survive but also contribute to better functioning markets. This is evident in their continuous efforts to fund, invest and support AI related projects. The chapter has successfully portrayed bank soundness in the face of AI through the lens of CAMELS. The taxonomy partitions opportunities into distinct categories of 1 (C), 6(A), 17(M), 16 (E), 3(L), 6(S). The results re-emphasises AI's advantages as being countless and numerous in helping banks to deliver world class services to its customers through efficient and effective processes. However, future study should look to investigate further the use of AI in capital and liquidity aspects as these are the core determinants of bank survival but for now, AI allows banks to survive and evolve. As such, it is a done deal.

Appendix

Government Support	AI & Banks
	Competition and Survival Nature of Banking Industry Future customers Beyond human capacity
	<i>Opportunities</i>
Capital	Stress Testing
Asset	<ul style="list-style-type: none"> • Unstructured data help increase number of eligible customers • Better evaluator and assessor of credit risk • Increases processing speed • Works with large dataset effortlessly • Improve loan process in terms of inconsistency, inaccuracy, biasness, and bureaucracy • Creditworthy assessment beyond the norm

Management	<ul style="list-style-type: none"> • Risk Assessment • Structured and systematic service from start to finish • Outperforms humans • Performs various important task with less supervision • Economies of scale and scope • Affordability • Increased ROA/Profit margins • Outsource boring, repetitive, physically exhausting task • Real time, organised, systematic record keeping • Future decision making • Surpasses cybersecurity • Market surveillance • Applies real time in crime prevention • Studies customers behaviours closely to detect crimes • Validity and reliability of data • Tracking decisions • Big data
Earnings	<ul style="list-style-type: none"> • Customer loyalty and retention • Understand emotions • Personal Advisor 24/7 • Respond in various languages • Real Time updates • Customer records • Standardise services • Product innovation and telemarketing through data mining • Opening up new market niches • Inclusion • Improved customer decision making • AI strict adherence to rules and regulations • More trust • Ethical Advise • Better advise due to lack of emotion • Improved end user experience
Liquidity	<ul style="list-style-type: none"> • Sort bank notes • Detect liquidity problems • Optimise cash management
Sensitivity	<ul style="list-style-type: none"> • Keep up with changes instantly • Derive meaning • Pattern detection and interpretation • Identify relationships • Process data beyond statistical methods • Robust predictive models

Table 1.
Taxonomy of opportunities posed by AI on bank soundness.

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Author details

Charmelee Ayadurai^{1*} and Sina Joneidy²

1 Durham University, UK

2 Teesside University, UK

*Address all correspondence to: charmelee.ayadurai@durham.ac.uk

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