

The Future of Cashless Economies Through Big Data Analytics in Payment Systems

Kishore Challa¹

¹Lead Software Engineer, Mastercard, O'Fallon

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Abstract

Big Data has become the buzzword for the past few years. Today, almost every business, big and small, is practically sitting on a Data Gold Mine. In terms of size, its growth is so rapid that it is doubling every two years. There has been a relentless increase in aspects related to Big Data. The exponential growth in both the volume and variety of Data indicates that there is a paradigm shift from traditional Banking and businesses to Data-driven Banking or businesses. No organization can survive, let alone compete, on their past achievements and successes. They have to reinvent themselves to be relevant in today's world. That means they have to evolve into Data-driven Organizations the Sooner the Better. Industries that are yet to migrate to a Data-driven Organization/Digital Organization will likely see their relevance being put in question.

Cash is the storage of wealth that is convenient to exchange for goods and services. There hasn't been a Treasury Department or Central Bank in global history that has hatred towards Currency. Nonetheless, when Cash Transactions are neglected, threats and complexities are expected to rise. A Cashless Economy means that a population uses financial assets not manifested in physical form. Transactions are settled using electronic, digital means. The centralized banking system keeps registers of the financial assets of its customers with distinct IDs or Digital IDs. Customers can redeem physical Cash from their accounts subject to regulation. Banking Institutions keep the highest currencies. The risk of using Cashless Payment Mechanisms is that Lawbreakers tend to transfer their assets to Smarter Nations to evade national Governments. Payment Systems should be meticulously designed taking all possible manipulations and threats into account. Big Data is analysed to provide sufficient and satisfactory answers to all payments questions from a broad array of user classes in Cashless Economies.

Keywords: *Cashless economy trends, Big data in digital payments, Future of cashless transactions, Data-driven payment systems, Analytics in cashless economies, Digital payment infrastructure, Big data for financial inclusion, Predictive analytics in fintech, Contactless payment analytics, Cashless society technology, Payment behavior analytics, Real-time payment insights, Data-powered financial services, Smart payments using big data, AI in digital payment systems.*

I. INTRODUCTION

The advent of technology has led to the development of cashless payment systems worldwide. Cashless payment systems involve payment for goods and services through electronic transactions via credit cards, debit cards, smart cards, and mobile banking. The cultural upheaval and proliferation of technology have altered business transactions in the commercial sector as well. As economies shift from cash to cashless systems both in urban and rural areas, this tendency offers exciting prospects for payment system advancement. Big data analysis of cashless monetary transactions in payment systems, including net banking, credit cards, debit cards, and mobile banking, provides additional prospects in the form of value-based and attribute-based intelligent recommendation systems. There is useful information

hidden within the vast amounts of data linked to the transactions made using cashless payment methods. In an organization, analysis of the data created through business transactions can assist in automatic prediction of consumer purchasing behavior, assistance in product planning, and formulation of revenue predictions and properly managing the resources accordingly.

Intelligent analysis of transactions made at company worksites can assist in formulation of business plans.

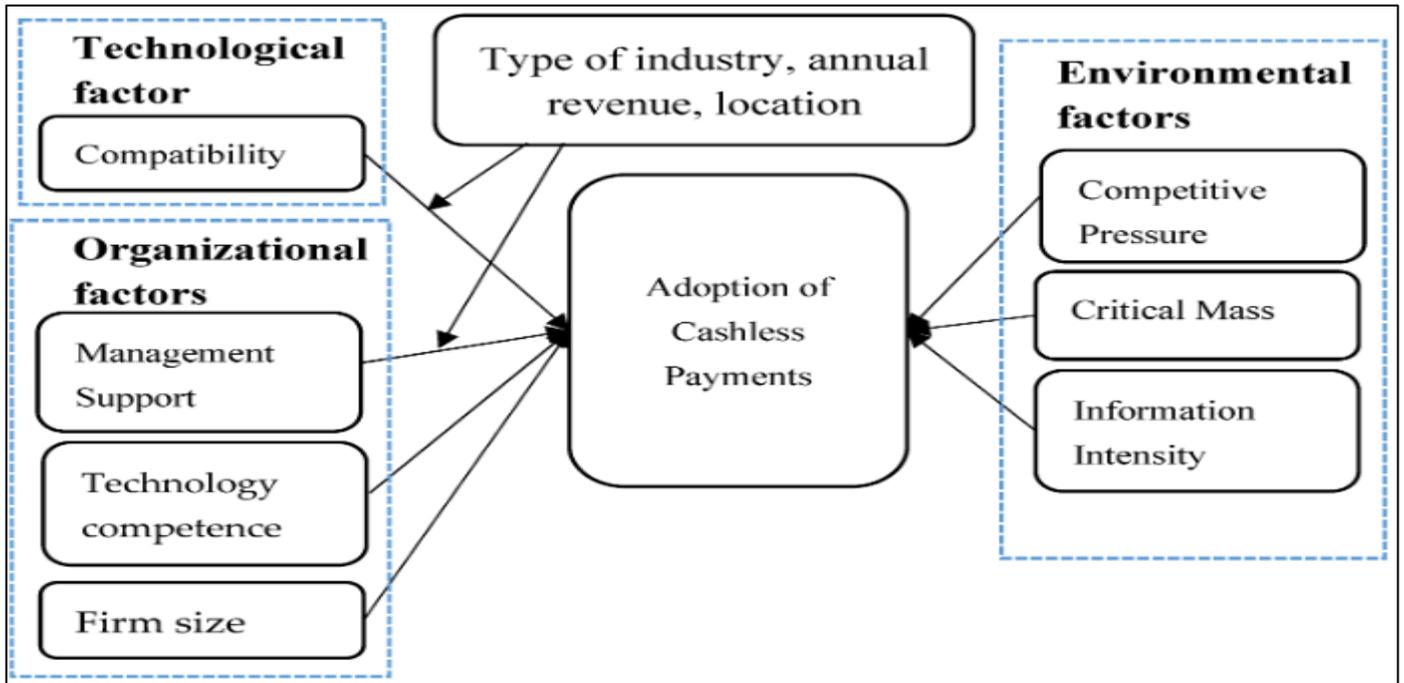


Fig 1 Cashless Payment Systems

➤ *Background and Significance*

The increase in cashless transaction systems has drastically lowered cash utilization, causing major banks, companies, and national economists to explore alternate forms of money. Big Data analytics along with Discrete Event Simulation (DES) is helping to identify, evaluate, and demonstrate new payment models or means, especially with Faster Payments Services (FPS) and Distributed Ledger Technology (DLT). Such simulation builds a futuristic cashless model by using voluntary & transparent real-time Big Data Analytics and Artificial Intelligence (AI) models for collective actions, which identifies and evaluates merits, drawbacks, and changes needed for successful implementation. Prioritizing such cashless systems may not eliminate cash but reduce its circulation. The exploration impacts money's role in policy-making, monetary policy, cash withdrawal, public trust, and security. The payments universe is gradually moving from physical cards, banknotes, and coins to chips embedded in wearables and possibly biometric measures, where risk and privacy concerns likely persist with the transition.

Over the past three decades, the strategy used to promote cashless transactions decreased from currency notes to credit cards and, through Internet of Things (IoT), ai-based devices with digital fingerprints to artificial agents. The speed of such transactions has increased to micro or nanoseconds with advanced security measures. Cryptos, coinless systems like toll booths, and government currencies running on blockchain technology and cash-equivalent digital currencies are now available with additional search. The digital divide with socio-economic inequity and awareness would dump several causative factors during adoption, operation, & implementation though it might be relatively free from other fundamentals of a fiat-based economy like monetary policy.

Consequently, there is a need to rethink coin and cash revenues, employment in banks and startups, and the accountable agency, ownership, concentration, and the need for cross-monitions in distributed ledger technologies.

Equ 1 Cloud Cost Optimization Function (Compute + Storage)

$$\text{Total Cost} = C_{\text{compute}} \cdot t + C_{\text{storage}} \cdot s$$

- C_{compute} : Cost per unit time of cloud compute
- t : Time used
- C_{storage} : Cost per GB
- s : Storage used

II. OVERVIEW OF CASHLESS ECONOMIES

A cashless economy is defined as being capable of transacting or purchasing goods and services without physically paying or receiving cash. This is enabled through guidelines and measures put in place by an economy's government which allows for goods and services to be transacted electronically through either a business or financial institution. A cashless economy is very effective in ensuring that criminals are incapable of operating physically in an economy. This is because criminal operations such as drug smuggling, drug trafficking, and money laundering as well as many frauds take place through cash. In a cashless economy, a crime will require cash transactions to be completed, therefore increasing the probability of being caught. When in a cashless economy, those that continue to operate with cash

will realize that there is not sufficient money available and would eventually stop operating. Apart from the criminal perspectives, a cashless economy ensures that the economy runs smoothly. There are times when there are coin shortages affecting businesses. As time goes on, it becomes more effective for those implementing cashless policies to develop measures that ensure optimum functionality of the systems.

With technology increasing in speed with every passing second, it has become increasingly important for those living in developing nations to adapt faster before becoming completely irrelevant in the future economy.

Technology has been part of human life since its inception. It is defined as the application of science to the practical problems that human beings encounter or the totality of the means employed to make or use goods and services. This definition includes both tools and machines that satisfy human needs. Technologies are commonly invented for man’s basic needs of survival, but in today’s society, they are the means through which social image is created. People have become more focused on outer appearances and the perception they leave on others. It has become evident that the wealthy outlive those below average income brackets.

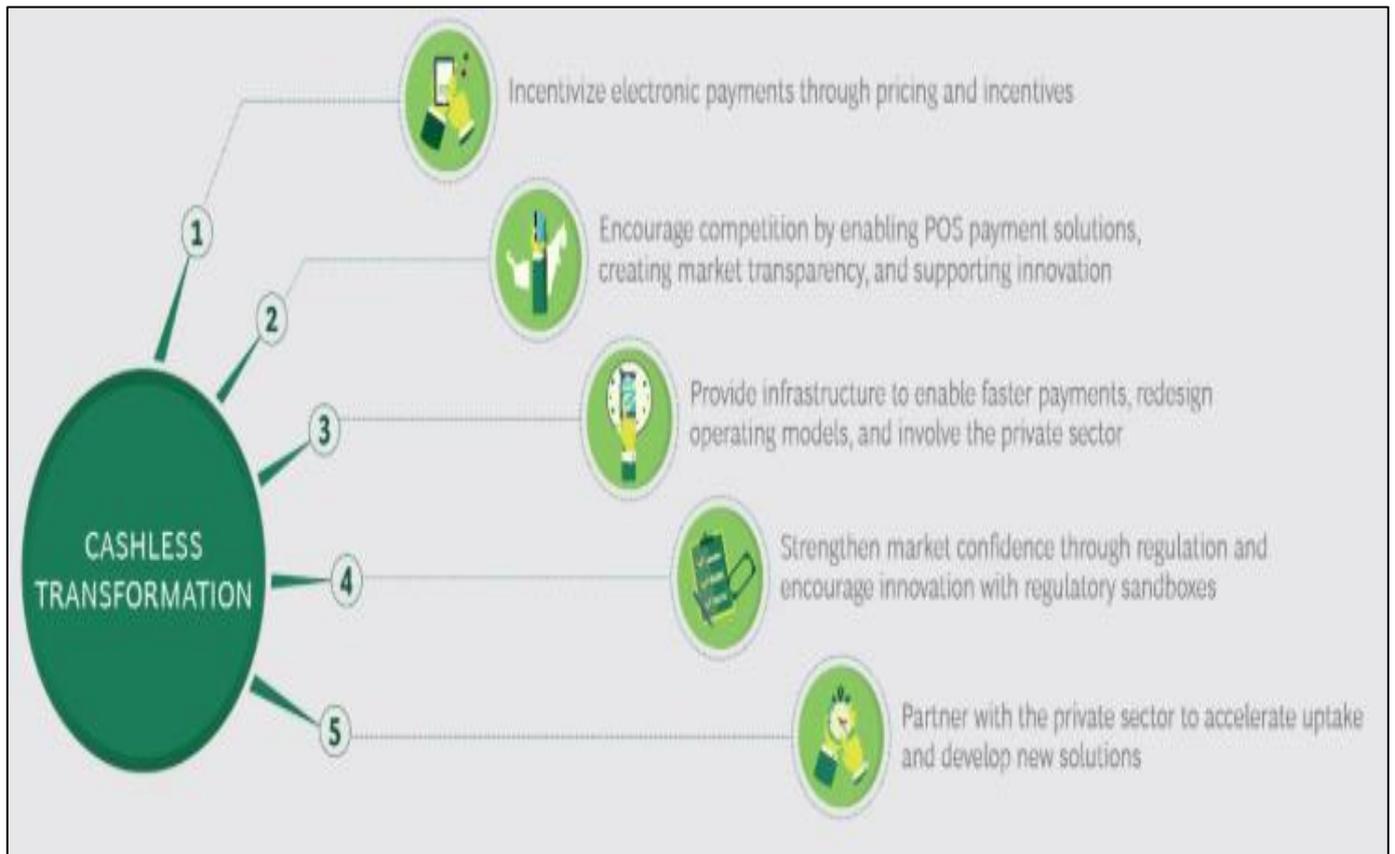


Fig 2 Cashless Payments Economies

➤ *Research Design*

The structure of the study is built on paradigms and design choices, providing the philosophical framework for gathering and interpreting data. The sequential order of study and collection approaches in the case of mixed methods is specified. The research design also takes into consideration the time dimension. Depending on the time frame for data collection, the research is categorized as a cross-sectional case study design if conducted at a single point in time, while a longitudinal design is chosen if various points in time are incorporated. To accomplish the objectives of the study, a structured literature review will be performed to identify key scholarly articles in relation to payment systems, specifically focusing on notions and aspects of big data analytics. The study will also classify the reviewed articles into categories relevant to various facets of payment systems and big data analytics. A search for target articles was conducted in indexed journals via the.

The analysis of past and ongoing payment systems could be useful in inspiring future development directions or implementations. This study focuses on the literature regarding payment systems as a whole and big data analytics in relation to such systems. The goal is to determine prospects for cashless systems with rising population scenarios and expert big data analytics. In addition to a literature review regarding payment systems, big data analytics, and recent and ongoing initiatives, expert evaluations will be held in order to explore potential advancements and development paths. Finally, the outcomes will be evaluated and used to create recommendations based on expert knowledge, material from the literature, and contributions stemming from peer-group work for payment system stakeholders, designers, and developers.

III. CHALLENGES AND RISKS OF CASHLESS SYSTEMS

With rapid technological advances, digitisation of financial services is the future. Throughout history, cash has played a pivotal role in the economy. Due to its many shortcomings, it is often recognised as a troublemaker and no longer useful. Cash has its disadvantages in terms of increments in black money, taxation problems and bribery, ransom, and theft. On the possible grounds of cash shortage in the informal economy and rising GDP, economies are starting to embrace cashless or plastic money card systems so that the world is approaching to go cashless. Concerns have been raised regarding the safety, security, and privacy of cashless transactions. Malware can harvest personal data from financial institutions and e-

commerce media systems, leaving individuals vulnerable to identity theft. There is the potential for serious privacy problems in electronic payments. Anonymity is rarely guaranteed because many electronic payment options require consumers to enroll in a program that tracks their buying patterns. Governments, corporations, and advertisers could also more easily monitor idiosyncratic preferences and behaviour, leading to manipulation and profiling. Tyranny also comes to mind, where governments monitor citizens by knowing their all purchases and activities using their cashless transaction profiles. Little by little the world goes to a cashless transaction economy. But we need to be very concerned and sceptical about its potential data misuse in our daily lives.

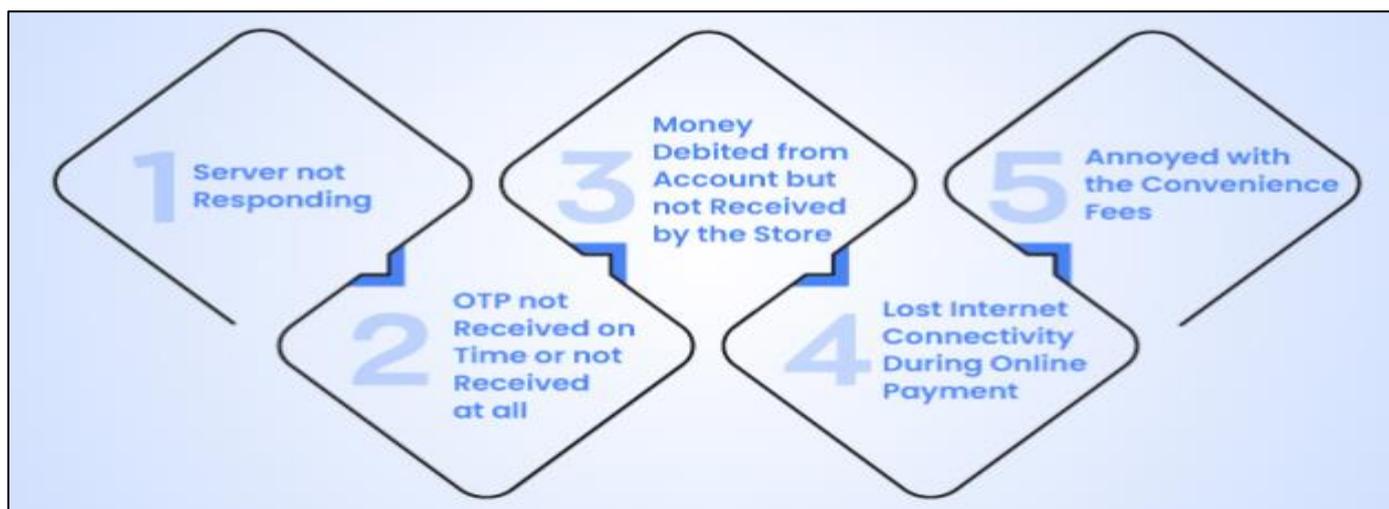


Fig 3 Cashless Payments Challenges

➤ *Cybersecurity Threats*

The cashless economy has its own drawbacks, which opens up opportunities for fraudsters to commit cybercrime on a grand scale. Cybercriminals are becoming increasingly talented by applying the latest intelligence innovations to financially benefit from breaches in online security, putting a greater degree of professionalism in the cybercrime arena. This results in even greater difficulties in ensuring safety and security in the cashless economy. The use of digital currencies and the subsequent rise of FinTech services and operators further aggravates these circumstances. Due to ease-of-use and cost-effectiveness, the growing acceptance and adoption of digital currencies push individuals and enterprises to use FinTech services. Conclusively, the global financial landscape is projected to experience an innovative boom fueled by the ubiquitous adoption of Digital currencies, generating massive transactional data. However, unless adequate safety measures are in place, the increase in data volume and diversity might lead to unprecedented Cybersecurity disasters across the globe.

To better conceptualize the most critical threats in the cashless economy against online safety and security, a comprehensive search in the Web of Science database was conducted to collect FinTech cyber-attack case studies. Obtained case studies went through rigorous screening,

synthesizing, and refining to eventually provide a deeper understanding of the cashless economy's cybersecurity threat landscape. The findings reveal multiple categories of cybersecurity threats to the cashless economy and corresponding defensive approaches that enhance the safety and security of the cashless economy in its various sectors. Further, the adaptive nature of FinTech services allows the cybercrime department to frequently change the pattern of the cyber-attack to target the specified casters of the FinTech.

➤ *Data Privacy Concerns*

Public interest, especially with respect to performance in cashless economies, public interest has to be well-fitted by strong disclaimers on behalf of companies which omit current Swiss customers' transactions for that they be extremely sensitive. Data pledges on behalf of companies should be frequent and as strong as companies' disclaimers. Disclaimers on the shape of contracts between firms and consumers also have to include a detailed warning about the higher potential risks (including financial and reputational) as well as a statement about the impact on firms that disclose the information. Currently, by following the law 4043 on comprehensive data pledges, companies deploy complementary high-resource competition-teasing disclaimers to exclude liability. Regulatory & Federal

agencies deserve to have such actions in defense of public interest. In this light, the raw data streams from oracles or even payment servers, must never be put in the public domain. Instead, a system must be designed to guarantee the data collectors immunity for machine intelligence-based undirected data collection. All global smart wallets transactions must be systematically stamped, thereby data collection would not be enacted during most time periods until minable pre-accumulations are reached. On the other hand, the dedicated contracts between equal parties could process this data first “clue-based” meaning that one of the party’s coins gets flagged as questionable, either during its transfer or holding. Since this is “preventable crime” (i.e. pre-accumulated data would get flagged previously before posing possible financial crimes), there is no doubt of stakes. Regulators may tune it with combination with multi-institutional privacy-prevention frameworks upon pre-trained adversary agents.

Equ 2 Forecast Confidence Interval (Assuming Gaussian error)

$$\hat{Y}_t \pm z_{\alpha/2} \cdot \sigma_{\hat{Y}}$$

- \hat{Y}_t : Forecasted value
- $\sigma_{\hat{Y}}$: Standard error of prediction
- $z_{\alpha/2}$: Z-score for desired confidence level

IV. CURRENT TRENDS IN CASHLESS PAYMENTS

The importance and influence of digital payments/great impact on interestingness/discipline shift/increased comfort with paybycoun etc. are what this paper studies. Digital payments are gradually growing multidimensional and can become a multi actor platform which brings all kinds of actors together. They allow for smooth transitions between payment tools, give more power to consumers, open up new business areas, etc. However, they will also bring new ethical, normative, and social questions as ongoing digitization and platformization at the same time reshape consumers’ roles, networks, and exposure affecting the representation and understanding of meanings of digital payments. The findings include all types of increasing influence on interest, diversity, multi actor interaction efficiencies, incl. prior anonymity issues, normative risks, and increasing discomfort which are positioning these payments as subtle yet strong facilitators of dynamism, entrenchment, and domination. These shift notions of agency, participation, segmentation/social sorting, transparency, and fairness, changing the designable boundaries of the future cash/cashless payments landscape. Finally, surprising findings on the shift in interestingness and engagement are discussed and research avenues and business opportunities proposed. The research offers novel insights and foresight into the intricate shifts in how various actors experience

cash/cashless payments. The articles elaborate on societal ramifications of cash and cashless payments and business opportunities through cashless payment systems in various settings.

➤ Mobile Payment Solutions

Since mobile payment transactions can be completed by making a few taps on a mobile device and much more quickly, easily, and conveniently than at a payment terminal, the payment processing speed can be improved without additional hardware. With better performance in cost and speed, mobile payment is expected to ensure a comfortable payment experience for the user in the era of cashless transactions. Unlike card-based payment systems, merchants in a mobile payment system inquire for a bank account in their own mobile payment app to process a payment, and only the bank balance amount can be accessed and spent by the merchant. Alternatively, merchants can also receive the payment amount by credit card through a payment robot that automatically connects with the credit card payment terminal in place of entering the card details. Payment systems using CCTV, light, sound, and vibration can allow merchants to send payment details to customer devices through miscues detected by privacy protection modules. The customer will initiate the payment process by confirming the details sent from the merchants, either using a card payment terminal through connection with the payment robot or sending a payment command to their bank accounts through their own wallet apps. Evaluation of scenario-based use cases will be performed with merchants to verify whether the payment method fits each merchant's business because only the bank balance amount can be spent by the merchants. To achieve a more comprehensive verification process, adjustment of the wallet apps will be needed.

From feedback of mobile payment developers, mostly banks and telecom-based service operators, hardware compatibility is critical for enabling testing matching mobile payment solutions and terminals with connected banks. Hence, in addition to sharing APIs, hardware compatibility designs and specifications will be prepared and shared so that system vendors can produce compatible devices with a wider semantic realm. Ways to filter out the vulnerabilities in the backend that hinder integration efficiently will also be studied with industry experts. Lastly, each solution’s differences from existing card payment and mobile wallet payment will be summarized and shared with the app and device development teams.

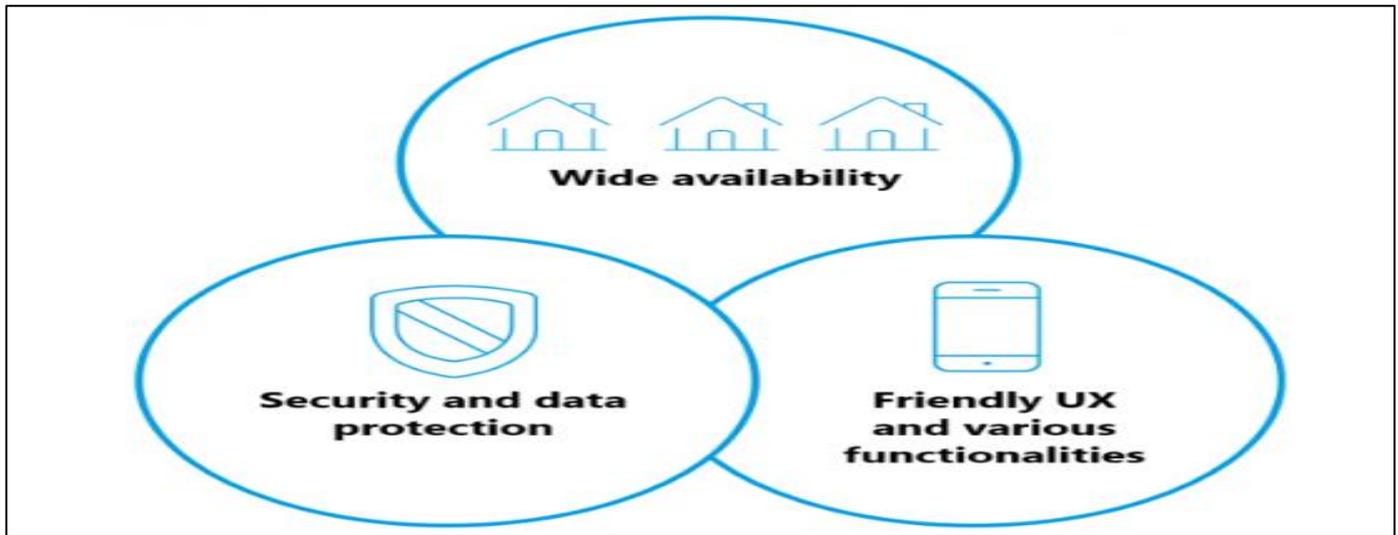


Fig 4 Mobile Payments

➤ *Cryptocurrency Adoption*

Evan Asano, Co-founder, and CEO of Onchain Capital, an innovator and a pioneer in the world of cryptocurrencies and blockchain technology, quotes that “Cryptocurrency has the potential to be the greatest innovation in history, if not the greatest.” Bitcoin is not only a cryptocurrency that can be accepted as payment on select websites, nor is it simply an investment vehicle that is mostly pegged to speculative bets. This futuristic electronic money is a decentralized digital currency that operates on a technology known as blockchain. Cryptocurrencies are specialized software and complex cryptography designed to prevent double spending while keeping transactions anonymous. Each piece of cryptocurrency is nothing but an entry in a distributed database maintained by a network of computers. It may seem pointless for someone to spend several hours and massive electricity to mine an entry representing a fraction of their currency. But each transaction has the potential to enchain data, which can be anything from purchase history to votes in an election. Bitcoin technology, and its first use case, is the foundation upon which future innovations, applications, and implementations in diverse industries will take prominence in the next 100 years.

In light of the ongoing COVID-19 pandemic, cashless payment systems in the form of credit/debit cards and mobile payment apps are proliferating across the globe. Considering the vast stakes involved in cashless payment systems, it is no surprise that many stakeholders are investing in the form of cashless payment products and platforms. Financial players such as banks are investing in development teams and products built upon legacy systems. Globally recognized technology players are launching their digital wallets. Telecom juggernauts across Africa, South-East Asia, and South America have launched mobile banking services relying on the ubiquity of mobile phones for the unbanked. Not surprisingly, self-proclaimed FinTech companies have drastically improved the consumer experience by leveraging the new capabilities of smartphones and the internet. In automating the payment process, payment players not only capture the

transaction data but also maximize payment efficiency. Given the building infrastructures, time-to-market issues are forcing regions and economies to develop their own cashless payment systems.

In Saudi Arabia, the Kingdom has launched the Vision 2030 initiative that includes the program of Path to Akhaliyat - the Saudi Payments System, aiming for 70% cashless transactions in 2020. Interestingly, the government’s dire effort has accelerated cashless transaction increases but also has raised the usage of cryptocurrencies like Bitcoin. Meeting customer convenience and regulatory issues, several payment companies recently built their ambitious futures around cryptocurrencies. It seems likely that as competition and technological development march forward, cryptocurrencies will be integrated into cashless payment systems. The use of quicker and decentralized blockchain technologies for immutable records would also need adaptation from payment players, even non-monopolized ones. The degree of cryptocurrency adoption among stakeholders and their concerns would help dissect the future of cashless payment systems.

V. BIG DATA ANALYTICS: TOOLS AND TECHNIQUES

The big data analytics field is expected to evolve further as more businesses enter the market and expend computational resources on their datasets. In addition, new subfields of big data analytics will continue to develop, such as analytics algorithms utilizing spatio-temporal data, other utilities that analyze 3D shape and graphical data, and various new types of data analytics problems in domains such as bioinformatics, physics, and social networks that have yet to receive attention.

Big data analytics can be useful to many business and scientific applications, and there is a growing need for big data analytics algorithms and systems. The problem of big data analytics has attracted increasing interest within the researchers' community, and many approaches have been

developed to overcome the challenges. However, most existing paradigms and systems were not intended for big data from the beginning and may not be able to keep up with rapid changes in usage scenarios and the explosion of big data. New algorithms, techniques, and systems had to be designed from scratch to handle the big data analytics problem.

Big data analytics is to analyze the large-scale data that were collected, transported, and recorded with various means and processes. While raw data and big data analytics could be applied to each other, they are indeed two distinct concepts: the former is output, and the latter is input/output. This scenario is analogical to a manufacturing process: data can be seen as raw materials before many improvements, while big data analytics are value-added products that derive from data collection and

processing efforts. Broadly speaking, big data can be classified into four categories by its types: systematic data, semi-structured data, unstructured data, and summarized data. The demanding efforts for big data analytics resources from governments, industrial companies, and research institutions in recent years are partly attributed to the explosion of data in the above four categories.

On a large scale, big data analytics tend to be more expensive than traditional data processing, data storing, and analysis. The high costs pay off if the results provide significant insights. In summary, big data analytics aim to generate value-added results and insights from huge-scale datasets, be they dynamic streams, massive collections, or large databases. Household members and companies of various applications create data to record their marketing, viewing, and searching histories.

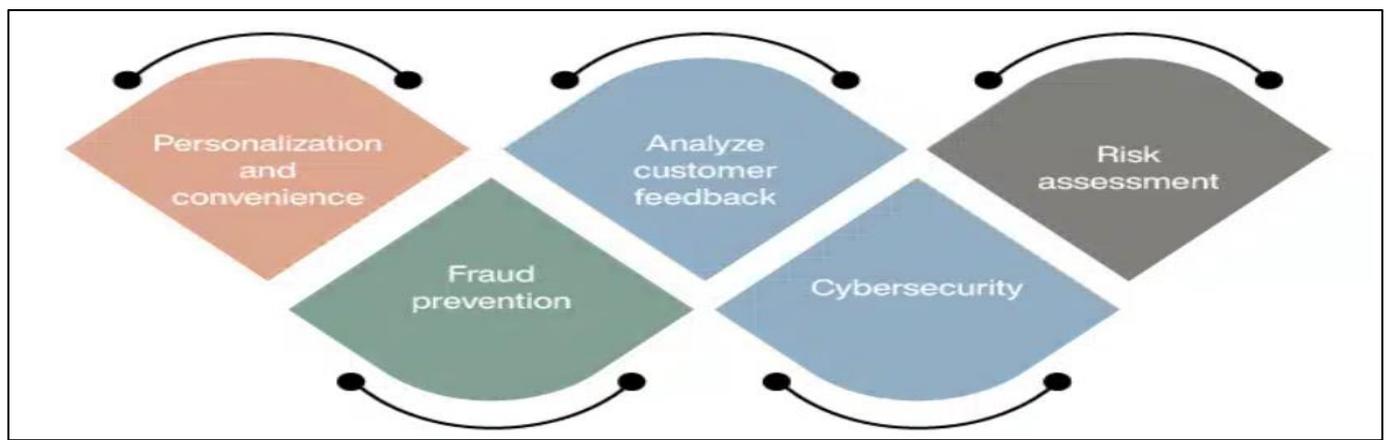


Fig 5 Big Data Analytic Tools and Techniques

➤ *Data Mining*

Big data has become a prevalent concept in many industries and has attracted extensive research interest. As one of the major industries that a vast number of financial transactions occur over the world, digital banking has also witnessed a rapid growth of customer data. The emergence of big data sets has driven banks to increasingly investigate new data sources as unmatched opportunities for data mining. Traditionally, customer history data from transactions and interactions were widely analyzed by banks for cross-selling and up-selling purposes. However, they largely lack data exploration aspects, and thus innovative measures have been increasingly explored in recent years.

With the development of the Internet and smart devices, a considerable volume of new customer information has been successfully recorded. A large amount of text data has been generated from social networks about banks and finance. In addition, banks also encounter various unstructured data sources, such as audio data from customer service phone calls, logging data from credit card applications, and video data from ATM machines. However, the understanding and application of this large volume of customer data remains a significant challenge for banks.

Consequently, in addition to bank-related data, challenges of data exploration in banks have been

discussed in both an academic and practical sense. Massive search engines can assist banks in acquiring non-relational and competitive intelligence datasets. Such big data sources have a quite different feature compared with bank-related data. For instance, social media posts have a significantly higher noise level, and distant search keywords cannot be applied in other countries, and thus require appropriate data mining methods to explore. In this regard, various unsupervised discovery and supervised categorization methods using natural language processing techniques will have promising applications in analyzing non-relational data such as text data, speech data, and user information networks.

➤ *Machine Learning Applications*

Recent years have seen increased credit card frauds affecting consumers and financial institutions. Millions of dollars have been lost by banking across the globe. As the number of transactions grows, it becomes harder for institutions to monitor the actions of consumers as transactions take place. Many banks rely on machine learning components to diminish the chances of false acceptance through authentication documents and other information. However, these transactions are completed on a daily basis and fraud spans many countries and territories, allowing identifiable markers to come from various places.

The use of the banking sector plays a great role in everyone's life. We make use of banking products in the form of online usage and physical cards. It is used in businesses, schools, colleges and each aspect of life. People of any gender and any age make use of banking products. These products bring convenience in life and smooth transactions. It keeps life running smoothly with all the expenses managed with the help of banks. However, this is also a treacherous sector as one bad decision or action taken might change the complete aspect of life in terms of loss and money. When you share the credit card details with a corrupt person or misplace it, fraud occurs. A fraud is an act of deception, practiced by an individual or group, with an intention to cause financial or personal loss. The term deception signifies that the parties involved in this transaction do not have the same expectation and as a result, one of them takes undue advantage of the situation. Fraud is an act of omission or commission that causes loss or damage to someone. Phishing and spamming is another form of online fraud. In this fraudulent act, either via email, message or missed call the user is invited to reveal personal details like ATM number, CVV number, passwords and much more.

Equ 3 Machine Learning Forecasting (Regression-based)

$$\hat{Y} = f(X) = w^T X + b$$

- X : Input feature vector (financial indicators)
- w : Weights learned by the model
- b : Bias term
- \hat{Y} : Predicted financial outcome (e.g., revenue, stock price)

VI. CONCLUSION

The way people conduct transactions has undergone a significant change. Cash has lost its physical presence and is on the verge of extinction in the thoroughly wired time. The explosion of E-commerce and drastic changes in means of cashless payment methods led to immeasurable economic transformations. There are many payment methods facilitating e-commerce transactions. However, to cater to increasing customer expectations, there is a need for stricter control of cashless transactions. Consequently, the demand for and relevance of Big Data are anticipated to grow exponentially in the coming decade. Digital transactions are accurate enough but may introduce costs that offset the worth of the transaction in terms of time saved. Existing methods for detecting and preventing money laundering, terrorist financing, and other financial crimes are based on manual review of either customer records or transaction monitoring alerts. Still, this process is inefficient. Reservoir models, analytical delving of transaction networks, and other Big Data and analytical techniques must be forcefully enhanced to cope with these challenges.

Transitioning to a cashless economy remains a big challenge to date, with the volume of cash transactions significantly increasing. Aspects such as culture, business practices, infrastructure, age, and geography hinder the transition to cashless economies in developing countries. Competition and sustainable partnerships among the bank sector, regulators, and telecommunications are needed to evolve policies that promote to help banks beyond the usual five-year plan. Goods and services must also be branded, and awareness campaigns promoted on all media platforms. In developing nations, dread and lack of trust in technological security, inflation reduction or gain in parallel currencies, and enforced cashless policies are also reasons cash transitions do not take effect. Even though it may not be fully cashless, cashless policies through infrastructure and education could lead to adopting alternative currencies.

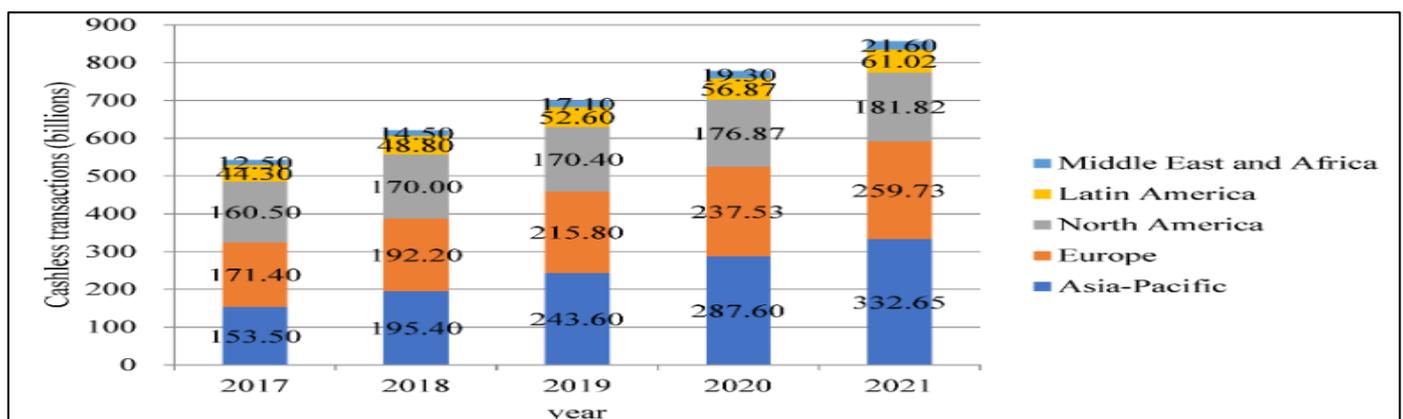


Fig 6 Financial Satisfaction with Cashless Payments

➤ Emerging Trends

The cashless economy is becoming a reality in many countries with the help of various payment systems. A large number of businesses are now accepting electronic payments over the internet. Even some of the street

vendors have upgraded themselves to becoming cashless. With the introduction of UPI and other mobile payment applications, surprisingly more and more people are now learning to transact the cashless way whether they are

literate or not. This prompts the people to learn to transact the cashless way at a faster pace than ever before.

There is growing interest among finance, sociology, psychology, and political science researchers to understand the cashless economy. However, the understanding of the cashless economy is still at early stages. Data handling in a cashless economy will be complex and will have to deal with large volumes of transactions. Most of the transaction data available is unstructured and will have to be converted into structured data to start processing it. Understanding customers' spending habits on a wide variety of parameters such as region, demography, time duration, weather, operational hours, holiday season, along with custom analysis of the social media footprint left behind by them is very important for any organization to plan and draw strategies accordingly for customer acquisition and retention.

Data analytics is the process of examining data sets containing a variety of data types to uncover hidden patterns, unknown correlations, market trends, customer preferences, and other useful business information. Data analytics enables organizations to make better decisions and quantify risks. Payment data analytics helps organizations know their customers in a better way.

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