



Emerging technologies:
Restructuring the fundamentals
of financial services



Foreword from PwC

The financial services industry has always been at the forefront of innovation and has continued to witness numerous digital disruptions across the value chain. This has further accelerated post the pandemic. The conventional methods of banking and other financial services continue to be disrupted by FinTech start-ups that provide alternative digital methods which are more customer-centric, customised, efficient and cost-effective. Moreover, customers are more accustomed to the improved experiences offered by digital products that are interactive, have user-friendly interfaces and robust support systems. The tech-enabled financial services ecosystem has been changing the way end users interact digitally in their day-to-day life. Also, it has significant influence on how companies design products, enhance customer experiences and facilitate processes that improve business models and unit economics. This fast-paced digitisation is regulated and driven by a positive policy and regulatory environment provided by multipoint ecosystem stakeholders.

In 2022, there have been considerable shifts in the financial services industry, which is gradually moving towards prudently adopting the value gains from the next wave of emerging technologies. Technologies such as artificial intelligence, cloud computing and blockchain have already established innovative use cases in the financial services industry. Other emerging technologies such as quantum computing, edge computing and the metaverse are still in the early phases of adoption at present. These may have large future implications in areas like customer experience, cybersecurity, portfolio optimisation and risk modelling. Currently, many organisations, especially FinTechs equipped with such emerging technology expertise, are all set to revolutionise the entire value chain within various financial services.

It is important for incumbent and emerging financial institutions to adopt these technologies in their product portfolios in order to stay competitive and secure the overall progress of the industry. Partnerships between various incumbents and FinTechs offering emerging technology solutions are on the rise. Recently, more than a dozen banks in India came together to form a new institution that will employ blockchain technology to process inland letters of credit (LCs). The LCs – which would take four to five days to process previously – will now be processed within four hours. This will also mitigate the potential risk of fraud since the LCs will be encrypted via blockchains, and there will be no way for two LCs to be issued on the same invoice – a common drawback of the traditional process.¹

Such initiatives will positively impact financial inclusion and credit availability, catering to the underserved segments of society. A relevant example is that of a firm which built a decentralised insurance policy aimed at protecting small farmers in Africa. The application offers farmers weather index insurance that uses smart contracts to trigger payouts when extreme weather situations pose a threat to their crops.²

This report highlights some of the key emerging technologies and their impact on the financial services ecosystem. It also looks at potential policy and regulatory developments that could influence the financial services landscape.

We, along with Invest India, are pleased to share our outlook and insights into how emerging technologies can benefit the financial services industry.

Vivek Belgavi and Ashootosh Chand

Partners,
PwC India

1. <https://www.businessinsider.in/cryptocurrency/news/sbi-hdfc-icici-and-12-others-banks-are-joining-forces-to-use-blockchain-to-power-letters-of-credit-a-move-that-could-be-a-boon-for-msmes/articleshow/83570874.cms>

2. <https://blog.chain.link/chainlink-awards-grant-to-support-the-joint-venture-between-acre-africa-and-ethereum/>

Foreword from Invest India

In the last decade, there has been considerable development and widespread adoption of FinTech globally, and India has come to be recognised as a strong FinTech hub. A fast-emerging sector, FinTech has immense potential to augment the functioning of the banking and financial sectors by improving efficiency and promoting equity and reducing the problems of inequality in society. With the highest FinTech adoption rate, India is already leveraging the viable opportunity presented by this sector for the future of the economy.

During the COVID-19 pandemic, when the majority of the economy experienced a slump in growth, the FinTech sector thrived in India owing to the increase in contactless transactions. This growth can be attributed to the collaborative ecosystem which is supported by key Government initiatives. Currently, India boasts of more than 6,000 start-ups working in the FinTech sector.³ These numbers are expected to maintain their upward trajectory as the entrepreneurial landscape in India continues to evolve and grow. The sector has various subsegments – payments, lending, wealth management, regulation, insurance and neobanking – each of which is unique and has the ability to revolutionise society and the economy.

Rapid digitalisation, increasing penetration of smart devices, emerging technological solutions for imminent problems, a conducive cultural landscape and favourable Government policies have facilitated unprecedented and large-scale adoption of FinTech solutions. In this context, how can new and upcoming technologies such as blockchain, Web 3.0, and augmented and virtual reality (AR/VR) be incorporated into the designing of FinTech solutions? In addition to an in-depth look at this aspect, this report by Invest India and PricewaterhouseCoopers (PwC) aims to explore potential opportunities for Indian and global firms and serve as an extensive repository of information to all investors and policymakers. My compliments to the authors for bringing out this insightful knowledge resource.

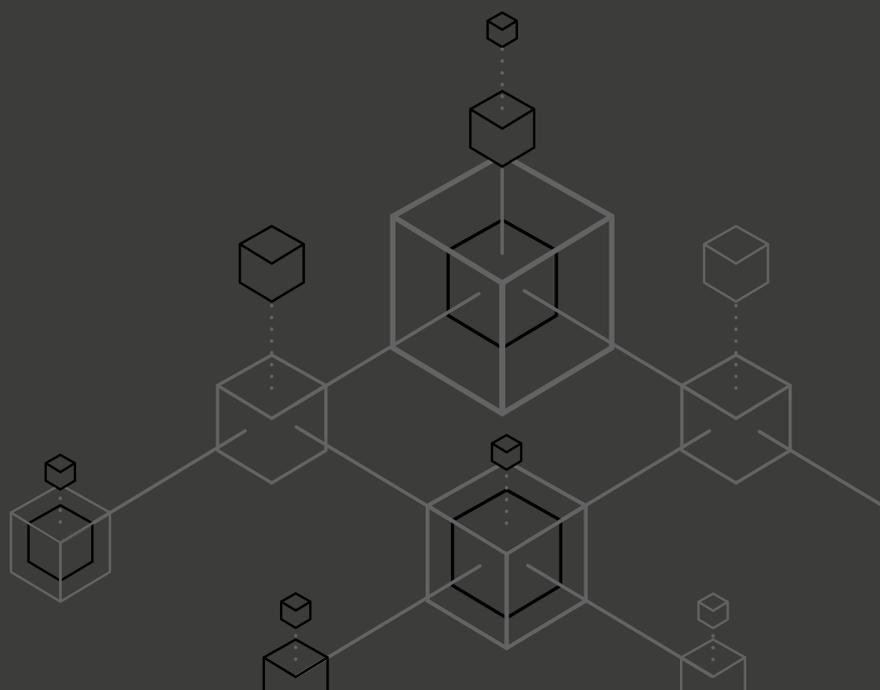
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Invest India

3. <https://www.investindia.gov.in/sector/bfsi-fintech-financial-services#:~:text=global%20FinTech%20Superpower-,India%20has%20the%20highest%20FinTech%20adoption%20rate%20globally,~%24150%20Bn%20by%202025>

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01

The tech-led financial services industry

Over the past decade, the terms ‘technology’ and ‘disruption’ have become synonymous, with the emerging technologies at the forefront. Some of the most widely known ones include artificial intelligence (AI), advanced analytics, internet of things (IoT) and robotic process automation (RPA). The growth and development of these emerging technologies have catered to an ecosystem driven by the advancement and expansion of start-ups, which has aided India to re-position itself among the top contenders in this era of new-age technology.

The next wave of emerging technologies is centred around the themes of decentralisation, efficiency gains, immersive customer experience and security. According to PwC’s Global CEO Survey 2022, the increasing adoption of blockchain technology can be attributed to factors such as global concern over privacy issues and information flow, as corroborated by 49% of global CEOs who considered cyber risk as the top threat to their organisation.⁴ This has led to the faster adoption of blockchain globally, as well as in India. Some of the major reasons for accelerating the growth of blockchain as a solution are high transparency and increased efficiency. These blockchain technologies have given rise to new financial services models including decentralised finance (DeFi), cryptocurrencies and token-based economics.

Financial services companies have also continued to capture the market through differentiated and immersive customer experiences. With the immense growth of digital adoption, data volumes and points of interaction have also increased considerably. While cloud strategies have revolutionised approaches to provide unified customer experience, emerging technologies such as edge computing have started to gain traction through their localised and distributed approach. This change has accounted for a significant increase in cloud efficiencies.

The top contributing factor to the growing interest in edge computing is the advancement in multifaceted devices we see today, along with their data acquisition and enhanced utilisation capabilities. Edge computing as a business solution resolves critical challenges like low latency and high bandwidth through higher computing capability. These factors will drive the advancement and rapid adoption of edge computing. India is on a path of accelerated 5G infrastructure deployment, which will further aid the adoption of edge computing in the coming years.

Another nascent emerging trend worth tracking is the shift from transistor-based computing to quantum computing. Quantum computing offers higher efficiency advantage for solving specific types of computations, with the ability to tackle huge volumes of data. Additionally, the speed and data-managing capabilities of quantum computing have resulted in its increased adoption, including its increasing interest in the financial services space. About 92% of the projects initiated in quantum technologies in India are sponsored by the Government.⁵ Moreover, the quantum computing market in India is expected to contribute USD 310 billion to the Indian economy by 2030.⁶ Globally, the quantum computing market size is expected to grow at a compound annual growth rate (CAGR) of 25.40% from 2021 to 2030.⁷

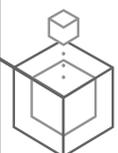
This report explores and discusses the emerging technologies of blockchain and its applications (Web 3.0, DeFi, metaverse) as well as the more nascent developments of quantum and edge computing. Moreover, potential use cases and the challenges faced in the wider adoption of the same in the context of financial services have also been discussed.

4. <https://www.pwc.com/gx/en/ceo-agenda/ceosurvey/2022.html>

5. <https://indiaai.gov.in/article/india-s-steady-moves-toward-achieving-quantum-supremacy>

6. <https://www.techcircle.in/2022/02/08/quantum-computing-could-add-310-billion-to-indian-economy-by-2030#:~:text=Quantum%20computing%20could%20add%20%24310%20billion%20to%20Indian%20economy%20by%202030,-Team%20TC%20&text=The%20quantum%20computing%20market%20in,maturity%20level%20between%202026%2D2027>

7. <https://www.globenewswire.com/en/news-release/2021/08/19/2283367/0/en/Global-Quantum-Computing-Market-Size-to-Grow-at-a-CAGR-of-25-40-from-2021-to-2030.html>



02

Applications of blockchain in financial services

A blockchain is a digitally distributed, decentralised and immutable public ledger that facilitates the process of recording transactions and tracking assets. Using this technology, individuals can enable secured transactions among themselves, without involving any intermediaries. The blockchain network shares a single version of the truth that enables users to access all the end-to-end transaction details, ensuring transparency and making it ubiquitous. To put it simply, it becomes difficult to hack and change data on the system. It is a digital ledger wherein the copies are distributed across the entire network of systems. The distributed nature of the technology requires authentication/verification at every entry or gateway by multiple independent entities.

These base properties of the blockchain technology have had interesting implications in terms of its usage in different contexts. We have discussed some recent applications below.

Existing blockchain use cases in financial services

Blockchain technology has already seen multiple use cases in the financial services space and is revolutionising different processes and value chains. A few such use cases have been highlighted below.



Banking: An Australian bank is using blockchain technology for the digitisation of bank guarantees (BG).⁸ BGs, which are traditionally manual and paper-based processes, can now be digitised using blockchain. The use of blockchain increases transparency, and allows easy tracking, reporting and validation. This helps banks to complete the BG process in a day, as opposed to the traditional turnaround time of up to a month.



Payments: Cross-border payments through blockchain have been enabled by a US-based technology firm. Real-time faster cross-border payments are offered at lower cost by the firm through the use of their blockchain-powered cross border bridge.⁹



Lending: A blockchain technology-based company was recently granted approval by the Reserve Bank of India (RBI) to test its blockchain-based micro, small and medium enterprises (MSMEs) lending product in the regulatory sandbox. The company has built a regulatory-compliant co-lending product enabled with blockchain for MSME loans to deliver credit with automated processes.¹⁰



Insurance: A Russia-based FinTech is currently offering the first peer-to-peer (P2P) insurance coverage service using blockchain technology. The product allows for an insurance policy that would be managed by a group of people. The group members will be able to define the insurance policy, premiums, claims and reimbursement rules. Moreover, the group will be able to make deposits in an Ethereum wallet, and reimbursements will be granted from the same once the claim is accepted.

8. <https://www.afr.com/companies/financial-services/scentre-anz-create-first-digital-bank-guarantee-with-lygon-blockchain-20210209-p570uu>

9. <https://ripple.com/insights/the-role-of-blockchain-and-digital-assets-in-cross-border-payments/>

10. https://www.rbi.org.in/Scripts/BS_PressReleaseDisplay.aspx?prid=53813

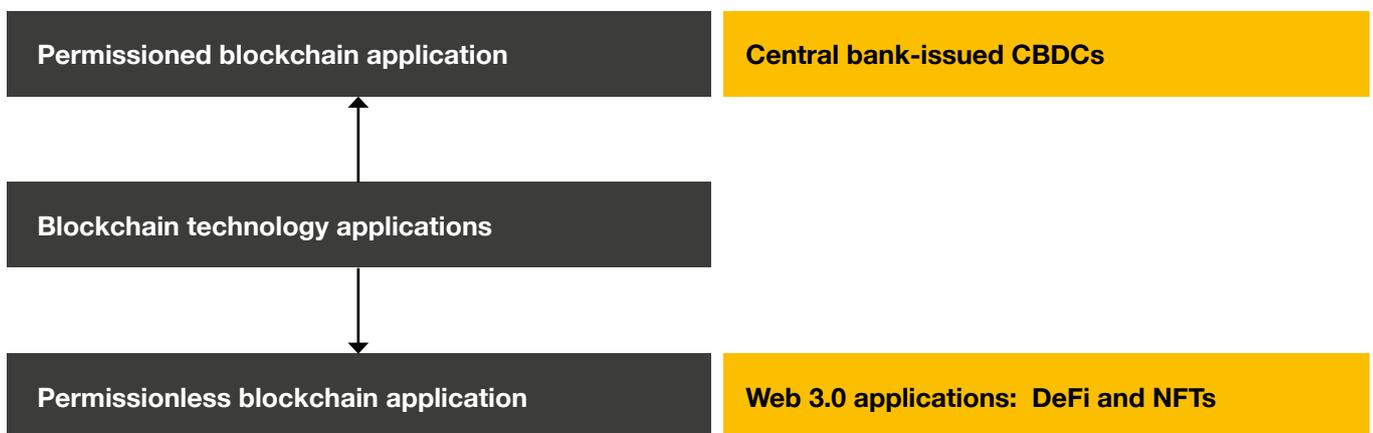


Emerging blockchain applications

Apart from the above-mentioned established use cases, blockchain technology has also facilitated an increase in the number of emerging financial services models and constructs such as Central Bank Digital Currencies (CBDCs), DeFi and non-fungible tokens (NFTs). Based on the type of blockchain model being used (permissioned

versus permissionless), its applications in the context of financial services vary. These properties have significant implications in terms of the type of use case and participating entities. We have highlighted some of the more recent applications below.

Emerging blockchain technology applications in financial services



Permissioned versus permissionless blockchain

Permissioned blockchain	Permissionless blockchain
Permissioned blockchain requires permission to join and participate in it. These can be accessed by people who have been allowed by the administrator.	Permissionless blockchain does not require permission to join and participate in it. It is also known as public blockchain as the participation is not controlled by the administrator.
Characteristics: <ul style="list-style-type: none"> • Has a governance structure put in by the organisation • Organisations can customise the networks based on their requirement 	Characteristics: <ul style="list-style-type: none"> • Open to all • Transactions are transparent – can be traced and read in public • Immutable

i) Permissioned blockchain application: CBDC

CBDCs are tokenised digital currencies issued by the central banks of a particular country. CBDCs are based on the secure and decentralised nature of the permissioned blockchain. They are the digital form of the fiat currency issued by the central bank of a country in lieu of the paper or metal currency issued, which is the direct liability of the central bank. This means that the CBDC of a country is denominated in the national unit of account. According to the Bureau of Indian Standards (BIS), 'In simple terms, central bank digital currency (CBDC) would be a digital banknote. It could be used by individuals to pay businesses, shops or each other (a "retail CBDC"), or between financial institutions to settle trades in financial markets (a "wholesale CBDC").'¹¹

Presently, central banks are in various stages of evaluating the usage of a general-purpose currency stored in a digital format. The Bahamas, Nigeria, Eastern Caribbean Union are some of the countries that have already launched their CBDCs.¹² Moreover, as of April 2022, India, China, Canada, the USA, the UK and other countries are working on their CBDC projects and testing out various use cases.

CBDCs function in real time and have potential advantages over traditional currencies. They reduce the settlement risk which can arise when the exchange does not happen simultaneously between banks in the financial system, like interbank transfers. Incorporating blockchain technologies in CBDCs could avoid the need for reconciliation between banks when a default occurs due to non-simultaneous exchange. Some applications of CBDCs include:

- **Programmable payments:** CBDCs can be programmed to be used only when certain conditions are met. This allows the automation of transactions based on the conditions and ensures the use of CBDCs for specific purposes only. For instance, CBDCs can be programmed by central banks for the purpose of employees' benefit distribution and Government subsidy distribution where the funds being remitted can only be used if certain conditions are met.
- **Cross-border remittances:** CBDCs can facilitate faster cross-border remittance payments. This would help countries to reduce the cross-border remittance cost and time through collaboration, for CBDC conversion and transfer. This collaboration and infrastructure development – which could ensure interoperability of CBDC across country jurisdictions – would be helpful for quick and real-time CBDC remittance.
- **Risk reduction in the securities market:** CBDCs can reduce risk in securities settlements as they can be automated using smart contracts.
- **CBDCs for retail payments:** Retail CBDCs upon distribution by Government and central banks would be stored in electronic wallets by end users to carry out retail transactions. These retail transactions with CBDCs have the advantages of instant settlement and low counterparty risk.

Illustrative case study¹³

To achieve interoperability among the new and existing channels for the provision of payments, the Central Bank of the Bahamas has launched Project Sand Dollar. The Sand Dollar is a CBDC through which the bank expects to increase transactional efficiency and reduce service delivery costs for financial services across the Bahamas. The features of this CBDC include real-time validations of transactions – which are fully auditable and yet maintain the confidentiality of the user. The retail application of this CBDC could help people to make and receive digital payments. Apart from this, the country is also planning to use the CBDC to provide instant aid and insurance payments to its citizens in case of natural disasters. Moreover, the country also envisions to reduce its dependency on cash and bring financial services to the underserved through CBDCs.

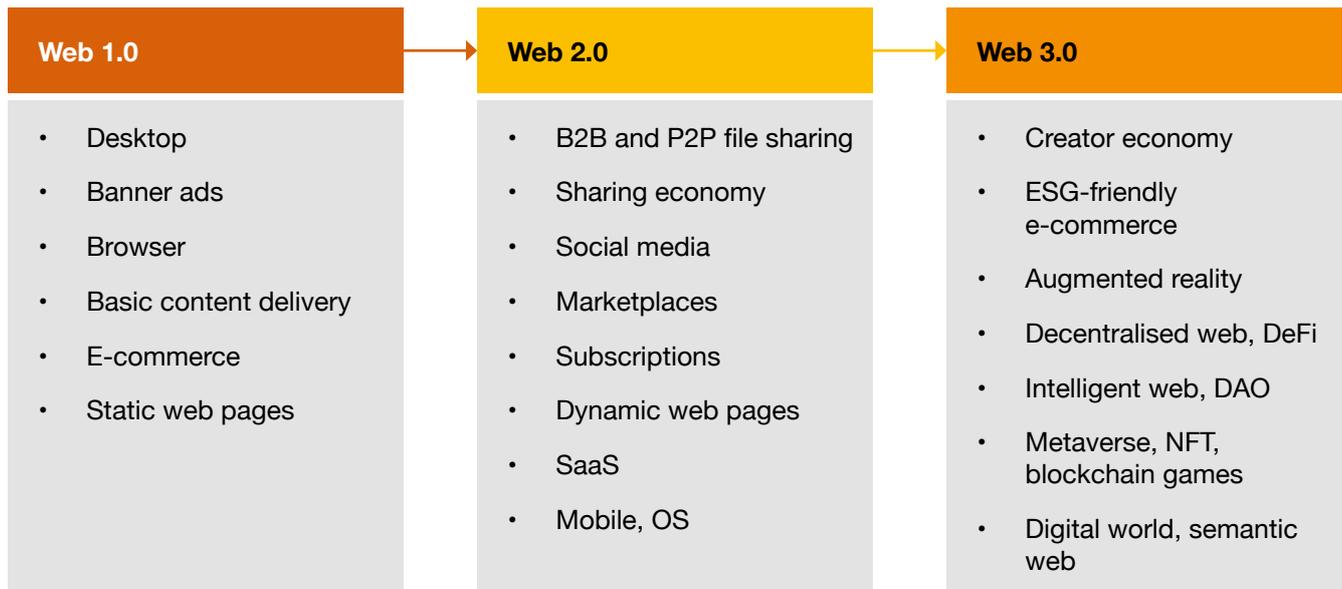
11. <https://www.bis.org/about/bisih/topics/cbdc.htm#:~:text=In%20simple%20terms%2C%20a%20central,a%20%22wholesale%20CBDC%22>).

12. <https://www.ndtv.com/business/here-are-the-timelines-and-status-of-central-bank-digital-currencies-in-some-countries-2820164#:~:text=Antigua%20and%20Barbuda%2C%20Dominica%2C%20Grenada,tested%20in%20a%20few%20countries>.

13. <https://www.sanddollar.bs/about>

ii) Permissionless blockchain applications: Web 3.0 – DeFi, NFTs and the metaverse

Evolution of Web 3.0



Web 3.0 is the third generation of the internet, which uses distributed ledger technology and machine learning (ML) to create a more connected, intelligent and open web. Web 3.0 has features like decentralisation, permissionlessness and trustlessness, which are achieved through the use of blockchain technology.

With the advent of Web 3.0, a plethora of applications like DeFi, NFTs and the metaverse have been introduced in the financial services industry.

Exploring DeFi

The concept behind DeFi is to offer financial services via a public P2P blockchain network, without the aid of any intermediaries or third party. Given that blockchain technology allows several entities to view and validate the history of transactions on its network in a decentralised manner, it essentially substitutes the centralised systems or gatekeepers. DeFi platforms are built on smart contracts, which are self-executing and run as programmed. Smart contracts eliminate the need for a middleman in a transaction as they are verified by all the involved parties on the blockchain. For example, fund transfers through DeFi can be facilitated via protocols that are automated on stable coins, and most importantly, the blockchains.

Thus, the DeFi system is cost-effective as compared to the traditional financial systems. DeFi-based chains have the potential to provide various financial services, some of which have been discussed here.

- **Payments:** Owing to the fewer intermediaries required for information verification on a transaction, the cost of B2B payments is significantly lower as compared to traditional systems.
- **Lending:** DeFi can be used in P2P lending as it eliminates the need for financial institutions and allows users to make instant transfers. Moreover, DeFi platforms can create protocols and smart contracts that automate many lending processes and define rules that are approved by all parties involved in the process. This reduces the transaction costs involved.
- **Asset management:** DeFi can be used in asset management wherein users can forgo the requirement for a manager, as services such as collateralisation and liquidation are automated. Under DeFi asset management, investors define how their investments and assets can be managed, thereby customising their portfolio according to their preferences.
- **Insurance:** DeFi could be used in the insurance space, where individuals will be able to define the terms of the insurance policies, conditions for claims through smart contracts and pool their collective funds into a common wallet for quicker disbursements.



Illustrative case studies

Lending: A UK-based start-up has created an open-source and decentralised non-custodial Ethereum protocol which enables users to participate as both borrowers and lenders for a blockchain-based cryptocurrency (DeFi). The platform allows borrowers to borrow in cryptocurrency or stable coin after providing an asset as a collateral. It also offers flash loans, which allow asset borrowing when the borrowed loan is returned along with the fees before the end of the same transaction.¹⁴

Loans for digital asset purchases: A DeFi-based FinTech allows users to invest in digital assets and partly fund the investments through multi-pool borrowing. Interested

investors put down a part of the investments from their own money, and the balance is provided by the organisation. The assets being invested serve as the collateral for the loan. Moreover, the type of asset being invested determines the borrowing rates. The loan operations are automated using smart contracts.

Exploring NFTs

An NFT is a non-interchangeable and unique digital asset on a contract-enabled blockchain. These digital assets can be created by and sold to anyone. NFTs have unique identification codes, provide proof of ownership and allow traceability. This provides opportunities for various financial uses by using digital assets.

NFT characteristics

Characteristics	Implications
Unique	NFTs are non-replicable. This means that with NFTs, it is possible to produce limited tokens with each token being individually identifiable. This is a direct driver of the token value, and the price it is sold and traded on.
Rare	Rarity is a basic element that drives the demand for any product. The scarcity of NFTs depend on the creator's perception, as they can control the scarcity of an NFT by controlling the number of copies made.
Traceable	Each NFT transaction is stored in a blockchain. This allows for easy traceability of transactions and ownership. Further, it allows use of NFTs as proof of ownership of underlying physical assets. This has useful implications for financial services products such as lending and insurance, where proving asset ownership is an important tenet of the value chain.
Immutable	NFTs are easy to audit as they are part of the decentralised blockchain and could be immune to fraud. This creates a layer of trust and transparency surrounding NFTs and their reliability can have positive implications for different verification processes in financial services.
Programmable	NFTs can be programmed so that their functionality can be modified over a period of time – based on certain conditions. NFT creators can also design them with programmable time locks and value-based unlocks, which could translate to potential use cases in the financial services sector dealing with collaterals.

14. <https://aave.com/>

Illustrative case studies

-NFTs as loan collateral

A South African P2P lending marketplace facilitates lending and borrowing loans using NFTs as collateral. The start-up allows users to register their NFTs as collateral, which then gets transferred into a double-audited escrow smart contract for the loan duration. Once the loan is paid, the NFT is returned before it expires. If there are defaults, the lender can foreclose and receive that NFT.¹⁵

-NFTs increase the liquidity of underlying illiquid assets

A blockchain-based diamond marketplace allows users to buy NFTs which represent ownership in physical diamonds. Diamonds are traditionally illiquid, given the volatility in their value post ownership. By owning an NFT as opposed to the physical diamond itself, the underlying value of the asset is more stable. This offers the opportunity to trade in diamonds via NFTs, thus making a traditionally illiquid asset liquid. NFT owners also have the option to cash in their NFT for the physical diamond.

-Insurance for NFTs

A UK-based company offers corporate and consumer protection to NFTs through an insurance-backed solution. The company protects customers' NFTs from hacking and other illegal activities while providing insurance-backed guarantees.¹⁶

Exploring the metaverse

The financial services industry is gradually introducing changes in customer interactions, by incorporating use of emerging technologies and the adoption of the metaverse. The metaverse is a virtual 3D environment based on technologies like AI, AR/VR and blockchain where users can engage in economic and social activities through their digital avatars. This new way of interaction and engagement has increased the number of applications in e-commerce, gaming and social media, each of which brings the need for frictionless financial services at the point of interaction or consumption. Financial services players are looking at the metaverse both as a new channel for customer interaction, engagement and acquisition, as well as a means for product innovation.

- The metaverse facilitates the creation of virtual platforms with 3D digital experience in financial institutions like banks, FinTechs and financial services organisations to interact and engage with clients and partners for acquisitions and boosting the bottom line.
- The metaverse platforms allow the use of meta wallets and payment services for users to make purchases on such platforms.
- The metaverse can also pave the way for the transaction of cryptocurrencies among its users, which could reduce transaction costs and fees for international transfers.
- Governments and financial institutions can also promote and develop financial literacy to end users through gamified approaches in 3D metaverse platforms. This could help end users to adapt to emerging financial applications.
- As more and more users, businesses and brands are flocking to different metaverse platforms and purchasing virtual real estate, new opportunities for investments and lending that can be financed by financial services lenders are coming up.

Illustrative case studies

A South Korea-based state-owned bank plans to offer banking services in the metaverse world to its customers. Through this plan, the bank is targeting a new customer segment of creators, artists and gamers to offer them services like income source aggregation, instant loans and financial planning.¹⁷

A US-based metaverse-developing company is currently providing users with the option of availing mortgage loans that allows them to purchase virtual real estate in the metaverse. The company evaluates borrowers based on their business plan in the metaverse, and the underwriting is not linked to the expected value of the digital asset in the metaverse.¹⁸

15. <https://timesofindia.indiatimes.com/business/cryptocurrency/blockchain/nft-lending-and-borrowing-growing-steadily-dune-analytics-report/articleshow/91739386.cms>

16. <https://www.coincover.com/>

17. <https://www.forbes.com/sites/forbestechcouncil/2022/03/15/banking-on-the-metaverse/?sh=5ceb88776068>

18. <https://www.forbes.com/sites/ronshevlin/2022/02/14/the-coming-boom-in-metaverse-lending-for-banks/?sh=6af7b1765984>

Challenges in implementing emerging blockchain technologies in India

1. **Infrastructure:** Blockchain-based applications – such as NFTs, cryptocurrencies and DeFi applications – require upgrades in the existing computer and mobile devices which come with native blockchain processing technologies. Thus, the existing infrastructure needs to be changed, which could be a potential challenge while implementing these technologies in India.
2. **Lack of awareness:** While digital literacy and access to digital technology continue to grow in the country, there is still a significant percentage of the population that does not currently have access to the relevant channels. This limits the scalability potential for such technologies. Furthermore, targeted efforts are required to build awareness and understanding of such technologies, even among the digitally initiated users in order to increase participation.



03

Data storage, computation and edge computing

An enormous amount of data is produced every day around the world. It is estimated that in 2022, we would produce 97 ZB of data.¹⁹ This will only increase as utility appliances like fridges, televisions, ovens and lights are being connected via sensors through IoT. Using IoT devices provides real-time data which can be used to derive actionable insights when coupled with AI and cloud technology.

The rapid increase in the amount of data being generated has outpaced the developments in data storage and transmission infrastructure. Earlier, the data collected was sent to either a centralised data repository or uploaded to the cloud for processing. However, the large amount of data being generated daily has led to the need for greater computational capacity and better storage and bandwidth. Also, data generated by businesses is processed more efficiently if it is closer to the source producing it.

An upcoming alternative to this centralised model of data sharing is edge computing. This technology comprises a distributed computing framework, using which data is analysed closer to its source (e.g. intelligent bots on a factory floor, smartphones, smartwatches, etc.), and processing power is moved closer to the source of the data rather than a server situated far away. Edge computing has the potential to considerably reduce latency as compared to the traditional centralised data-sharing models. Reduced latency would result in faster data analysis, leading to better insights and improved customer experience.

Use cases of edge computing in the financial services industry

Over the past few years, the financial services industry has seen an influx of products across multiple domains including payments, lending, WealthTech and InsurTech. FinTech players are currently working on providing differentiation through a seamless customer experience, regardless of the product type. Edge computing can facilitate this using its real-time data analysis capabilities. Let us look at some possible use cases for edge computing in the financial services industry.

- **Personalised financial products by banks:** Edge computing capabilities can help banks and FinTechs to offer highly personalised products to customers – down to an individual level – by advertising and offering products and services that would interest the customer. Such offerings would result in better customer engagement and higher customer lifetime value. Edge computing will prove instrumental in providing players with the necessary processing power at the point of interaction in order to offer greater analytical insights, real-time offer deliveries and more effective product offerings with greater conversion potential.

Personalised services such as virtual agents and facial recognition require real-time computational capability and would benefit from edge computing.

Using edge computing, financial services organisations can immediately process key data points and modify their offerings in real time – close to the point of generation. However, the key differentiating factor of using edge computing is the ability to perform this computing remotely, with very low latency. This technology could prove to be a game changer for retail banking. Bank branches could be set up anywhere in the world – be it a theatre, hospital or cricket stadium – to offer personalised products to customers by analysing their needs instantaneously through edge analytics and virtual tellers.

19. <https://www.statista.com/statistics/871513/worldwide-data-created/>

Illustrative case studies

1. A British multinational universal bank has recently launched a Japanese multinational conglomerate's robot in its US branches. The robot acts as an edge node and uses natural language processing to process customer requests. Moreover, it has the ability to alter its behaviour based on the perceived human emotions.

- **IoT data analysis for insurance companies:** Insurers use IoT devices for a variety of purposes – like tracking and monitoring pipeline and smoke sensors – to alert policyholders regarding hazardous incidents and help minimise the damage. However, using IoT generates a huge amount of data, which then needs to be monitored and analysed in order to be used. Here, edge computing can prove to be useful.

Using edge computing instead of the conventional cloud for analysing data from IoT devices can be cost efficient, more reliable and highly secure. Interestingly, the implications of using edge computing – especially reduced downtime and lower latency – become more crucial when responding to accidents or incidents relating to personnel or property.

As data processing occurs near the source of the data and not on a centralised server, the amount of data being transmitted centrally reduces, resulting in a lower cost. Moreover, owing to this proximity, the data processing can continue to function even if there is an interruption in the cloud connection, therefore increasing the reliability of data from IoT devices.

2. An American multinational technology company is currently working on edge computing solutions that can be used to analyse footage from ATMs in real time and respond quickly in case of potential risk scenarios, without human intervention. Similar technology can be used by insurance providers for protecting high-risk assets.

- **Algorithmic high-frequency trading (HFT):** HFT requires high-speed execution of orders. In order to ensure one is on par with the competition, managing latency is of utmost importance. Although most HFT servers are located in the exchanges²⁰ themselves to gain a split-second advantage on price information, this alone is not enough as communication is still required between different office locations, along with the price information from different exchanges. Edge computing can prove to be beneficial in this scenario as it can help to reduce the latency by valuable microseconds by processing the data locally and sending it to the desired location. Incorporating edge computing would eliminate the need to route the data through a centralised server, which would prove to be advantageous.

3. A US-based leading custom-hardware solutions provider is now providing solutions for high-performance computing (HPC), which focus on taking advantage of real-time data for fraud detection, risk management, portfolio optimisation and HFT.

Challenges in implementing edge computing

- **Remote installation:** Edge computing requires remote nodes with an increased level of processing capability. This means the initial set up of all the nodes is effort intensive and expensive, especially in rural areas. It is also crucial to create a node with a robust physical security mechanism, for it to withstand the harsh environmental conditions of remote areas.
- **Bandwidth:** Edge nodes like automated vehicles are estimated to generate nearly 40 TB of data per hour.²¹ These data points have to be seamlessly transferred and processed in fractions of a second in order to make quick decisions. Traditionally, more bandwidth is allocated to data centres than to endpoints. Thus, insufficient bandwidth to handle such critical data would be detrimental to the technology.
- **Data security:** As the data in edge computing is distributed throughout the network, an increased number of nodes are exposed to the possibility of cyberattacks. This means that hacking even a single edge device can expose the entire network to malicious attacks. Hence, it is essential to be wary of the underlying risks while designing the architecture of the edge devices and ensure that sensitive data is handled in a secure manner – especially edge nodes that are connected to a centralised database.

20. <https://indianexpress.com/article/explained/everyday-explainers/everyday-economics-what-co-location-heart-scram-nse-7799595/>

21. <https://www.financialexpress.com/express-mobility/autotechnology/role-of-cloud-computing-in-autonomous-driving-development/2338925/>

04

Introduction to quantum computing

Quantum computing is another technology that is revolutionising information processing. Classical computers take a sequential approach to data processing, which means that the computing power and time required to solve a problem are equivalent to the complexity of a problem.

As opposed to classical bits (0 or 1), quantum systems use quantum bits (qubits), which can theoretically

solve complicated problems quicker than conventional computers. The system's processing capability also grows exponentially when more and more of these qubits get entangled – i.e. share a single quantum state of being either 0 or 1.

The speed advantage offered by quantum computing systems directly translates to business value for enterprises working on problems requiring high computation, optimisation, cryptography and security.

Business applications of quantum computing

Computation resources

Heavy computation models (ML models) call for allocation of virtual capacity on a requirement basis due to the cost of classical computing.

Cryptography

Cryptography protocols following classical computing cannot process large numbers into their primes. However, quantum systems have the capability to break the existing systems.

Optimisation problem

Asset managers use computation-intensive models to optimise portfolios. Quantum computing systems would allow for quicker analysis to arrive at the right portfolio mix.

Use cases of quantum computing in the financial services industry

The effects and advantages of implementing quantum computing are far-reaching in multiple industries. This technology has the potential to impact industry verticals such as healthcare, finance, commerce, communications, security, cybersecurity and cryptography, energy, space exploration, and numerous other disciplines. Any industry where the usage of data is inherent to its operation will have a significant impact through quantum computing. The global market for quantum computing is expected to grow from USD 472 million in 2021 to USD 1,765 million by 2026, at a CAGR of 30.2%.²²

With the vast amount of data generated by the financial services market, activities surrounding financial services – like portfolio optimisation or pricing – can benefit by using quantum computing, which can help in assessing multiple outcomes through algorithms.

When we consider the capital markets, it is generally the buyers (hedge funds, private equity and venture capitalists) and incumbents (banks) that deal with highly complex problems. Consequently, these are currently investing in quantum computing, apart from the technology majors.

22. <https://www.marketsandmarkets.com/Market-Reports/quantum-computing-market-144888301.html>

Financial services players have often used physics to address and resolve some of the key challenges such as price formulation, price dynamics and market instabilities. Similarly, the first movers using emerging quantum computing technology could deal with problems like constrained optimisation and uncertainty.

- This could help in the calculations of dynamic arbitrages, better compliance, improved customer experience through behavioural data analysis and improved reaction time to market volatility.

Companies are also working on quantum computing applications in portfolio use cases that have applications in portfolio optimisation, instantaneous transactions and seamless trading experience.

Illustrative case studies

Wall Street majors are leading the fray in terms of quantum computing use cases. An American multinational financial services corporation has collaborated with major banks across the globe for their quantum computing programmes, working on areas like the calculation of value at risk (VAR) and optimising portfolio volatility.

A group of Dutch multinational banking and financial services corporations have ventured into quantum computing technology by stress testing some of the possible applications. The current research and development areas of focus are quantum cryptography, education and awareness. The programme also aims to have a social and financial impact through its implementation of these use cases.

A Canadian quantum computing company is working with an American multinational financial services corporation on a system that detects fraud through the combination of classical and quantum computing using ML.

A Spanish financial services company that is working on portfolio optimisation using quantum computing systems was able to process the information for a specific risk

profile type under three minutes, which had earlier taken 30 hours using classical computing systems. The company is also allied to work on portfolio optimisation and a better Monte Carlo model using quantum computing.

In 2020, a British multinational banking and financial services company stated that it was working on portfolio simulation using quantum computing systems, in collaboration with a US-based space research organisation.

Challenges in quantum computing implementation

1. Need for skilled personnel

India has allocated INR 8,000 crore from its budget towards quantum computing systems and their development.²³ To create a significant impact, India plans to groom over 25,000 personnel equipped with skills in quantum computing over the next seven years, through support from technology enterprises and academicians.²⁴

2. Need for capacity

Working on quantum computing systems requires working parallelly on various aspects like quantum information theory, communication, storage, computation and hardware development. Further, there needs to be a seamless connection between the different teams working on these areas. Although India is working on these, most of these developments are siloed. However, the country is making strides in terms of hardware manufacturing, especially in the semiconductor market, trying to attract global manufacturers through a USD 10-billion incentive.²⁵

The quantum computing systems will act as an enabler for many fields when combined with other emerging technologies and have the potential to be used in multiple industries. Although quantum computing still has a long way to go, it is definitely the right time to encourage its widespread adoption in the ecosystem.

23. <https://dst.gov.in/budget-2020-announces-rs-8000-cr-national-mission-quantum-technologies-applications>

24. <https://www.computerweekly.com/news/252513355/India-to-invest-1bn-in-quantum-computing>

25. <https://asia.nikkei.com/Business/Tech/Semiconductors/India-woos-global-chipmakers-again-this-time-with-10bn-package#:~:text=India%20woos%20global%20chipmakers%20again%2C%20this%20time%20with%20%2410bn%20package,-Previous%20attempts%20failed&text=TOKYO%20%2D%2D%20India%20has%20rolled,a%20high%2Dtech%20production%20hub.>

05

Considerations for policymakers and regulators

As the emerging technologies continue to see traction and global adoption, policymakers and regulators need to shape this adoption and usage to enable growth and safeguard against possible risks. The policies, interventions and guardrails that can foster the growth of FinTech models and emerging technologies in a responsible way should fulfil the following major goals:

- reforms must enable the building of a supportive infrastructure to promote services by encouraging the use and adoption of such infrastructure
- rules and guidelines must be formed and implemented to monitor the use of technology by market participants to ensure that no segment is being exploited
- policies to protect vulnerable sections of the society and at-risk customers as well as to prevent money laundering and terrorism funding are also needed.

In this section, we have discussed some key highlights in terms of regulations and policy interventions that would create a favourable environment for the growth of emerging technologies in the financial services sector.

Policy interventions

1. Data-sharing guidelines

Owing to the vast amounts of data being generated globally with more individuals and companies opting for digitalisation, organisations and governments have realised that this technological transformation can be leveraged to provide better quality targeted services and products

However, in order to be scalable, this transformation requires adequate protection rules and data privacy laws to ensure that personal and business data are used responsibly and enforce trust among the stakeholders. The regulatory aspects can be facilitated by encouraging the adoption of emerging technologies, such as blockchain and quantum computing. Adopting blockchain as a solution guarantees the fidelity and security of data records and enables trust with no external aid or third-

party dependencies. Blockchain adoption and usage by financial services firms may be deliberated upon by policymakers.

With Web 3.0 being free from any central authority and allowing consumers to buy, own, sell and earn by selling their services and content (for instance, in the form of NFTs), data available for use will only increase and diversify from here on. In fact, data is one of the foundational elements of newer innovations like the metaverse. This is to reiterate that policy regarding data sharing, albeit with a consent-based mechanism, is crucial to ensure the risk-free adoption of new-age technologies.

Aligning with the concept of establishing a data-driven economy, the European Parliament, for instance, has approved new rules to encourage intra-EU data sharing. To build trust in data sharing, the Data Governance Act (DCA) aims to formulate new rules related to data marketplace neutrality and enable the reuse of specific data under the public sector. These initiatives will be carried out under shared European data spaces in various strategic domains such as energy, healthcare, manufacturing, agriculture, environment, finance, skills and public administration.



2. Fiscal incentives and policy environments

Fiscal incentives and policy environments that promote the development of the FinTech industry and innovation can play a critical role in FinTech growth. The Blockchain District in Hyderabad, for instance, will house all major blockchain technology companies, a huge incubator, and a world-class facility for promoting research, innovation and industry collaboration.²⁶ It will provide land for companies at a subsidised rate, capital funding for research and development, and regulatory and policy support to start-ups.²⁷ This novel initiative has the potential to put all blockchain companies based out of Hyderabad in a strategically advantageous position globally. Similar policy incentives throughout the country will accelerate the adoption of new technologies.

To quote a few global initiatives, in South Korea, the Ministry of Science and ICT recently created a 'metaverse alliance' to coordinate and facilitate the development of AR/VR platforms.²⁸ Meanwhile, in China, a metaverse industry group, the 'metaverse industry committee', was formed under the state-supervised China Mobile and Communications Association in December 2021.²⁹

Facilitation of incentive-based initiatives targeted at start-ups working on solutions that utilise emerging technologies like blockchain, Web 3.0, NFTs, edge and quantum computing to solve problems in the financial services sector would aid in the scaling up of the supply side in terms of innovative products and services offered.

3. Cybersecurity

The advent of emerging technologies has also increased the scope for new types of financial frauds which require unconventional cybersecurity approaches. With FinTech, cyberthreats have become more expensive and riskier owing to the vast data stored online. To minimise risk and fraud, data needs to be desensitised and tokenised.

Data desensitisation is the process of deforming, bleaching or masking information that is sensitive in nature, in order to safeguard business-sensitive and private data. Likewise, data tokenisation is the method of swapping the non-sensitive data element in place of the actual data element. This form of substitution is done via a token, which holds no underlying, extrinsic or other value.

For example, as per the RBI's tokenisation regulations, e-commerce platforms would have to delete card-on-file information.³⁰ The RBI has encouraged FinTechs to prepare themselves for tokenisation, making use of innovative payment options safer for the masses. The Ministry of Electronics and Information Technology is also working on a zero-trust network access system and enhancing security using lightweight cryptography in underlying IoT communication networks, among other research and development being conducted to ensure future readiness.³¹ This could have an impact on quantum and edge computing as their underlying technology infrastructure could be leveraged for such research.

4. Digital financial literacy and capacity building

To empower users and prevent massive cyber and financial frauds, it is necessary to promote digital financial awareness and literacy to establish trust, safety and security to encourage the adoption of FinTech-supported financial services. While adding disclaimers before advertisements and on websites of financial services players is a mandate, the Government can insist on clearer communication and delivery of financial education to users of a financial service by emerging players (for instance, those players providing services related to NFTs, DeFi and the metaverse). This can be an efficient corporate social responsibility mandate that will reduce asymmetric information in the market without the extensive use of public resources.

In a novel attempt to promote the use of new technologies in financial services, the Department of Financial Services of the state of New York has started issuing official guidance for service providers on the adoption of specific technologies. It recently highlighted the importance of blockchain analytics in effective policies, processes and procedures, including those relating to customer due diligence, transaction monitoring and sanctions screening.³² Another example is that of the Organisation for Economic Cooperation and Development (OECD), which recommended that governments could strive to build human capacity by supporting education and training for all blockchain stakeholders on the skills necessary to understand and work with blockchains, where appropriate. This includes supporting fair transitions for those whose jobs have been disrupted and displaced.³³ Policymakers and regulators can incentivise emerging technology literacy and education programmes, which would multiply adoption and reduce fraud risks.

26. <https://blockchaindistrict.telangana.gov.in/>

27. <https://www.livemint.com/technology/tech-news/telangana-to-have-india-s-first-blockchain-district-woos-firms-with-incentives-1558862756949.html>

28. <https://www.msit.go.kr/eng/bbs/view.do?sCode=eng&mId=4&mPid=2&pageIndex=1&bbsSeqNo=42&nttSeqNo=621&searchOpt=ALL&searchTxt=Emerging+Metaverse+Industry+Promotion+Strategy>

29. <https://www.reuters.com/markets/funds/chinas-metaverse-industry-committee-admits-17-new-firms-2022-02-16/>

30. <https://rbidocs.rbi.org.in/rdocs/notification/PDFs/DPSSCOFTBA69C3B5B8CC4025AD089456DD857C5F.PDF>

31. <https://www.meity.gov.in/major-research-projects>

32. https://www.dfs.ny.gov/industry_guidance/industry_letters/il20220428_guidance_use_blockchain_analytics

33. <https://www.oecd.org/mcm/Recommendation-on-Blockchain-and-other-Distributed-Ledger-Technologies.pdf>



5. Regulatory and policy framework for innovation

As emerging technology adoption brings about a change in the financial services sector, it has become necessary for pertinent legal and regulatory framework be setup to prevent and identify obstacles and tackle any new risks which might arise. These frameworks should further ensure that consumer rights and data are protected. Many regulators around the world have developed various approaches – such as innovation offices, test-and-learn approaches and regulatory sandboxes – to facilitate safe experimentation and innovation.

The Monetary Authority of Singapore (MAS), for instance, has launched the FinTech Hackcelerator programme with specific problem statements related to Web 3.0. The problem statements include exploring the use of blockchain for more streamlined processes and scalability, as well as exploring use cases of DeFi.³⁴

Indian financial services regulators have already established their sandboxes that are dedicated to promoting FinTech growth through controlled and safe experimentation. These sandbox programmes can also be extended to specific cohorts which could work on use cases linked to emerging technologies like Web 3.0, and edge and quantum computing.

Based on the product, process and customer experience innovations that are seen through these sandbox programmes and other innovation initiatives, regulators might also need to consider evolving the product definitions and scope of existing product licences to encompass such innovations and changes.

6. Safeguarding consumers' interests

Effective consumer protection guidelines are necessary to build trust in order to have a positive impact on adoption. This can be done by providing transparency to consumers regarding the use of their data and how the services employed will impact them. Moreover, these guidelines will include rules that need to be put in place to prevent unfair market practices and appropriate complaint redressal mechanisms.

The adoption of the technologies mentioned above by the financial services players needs to be accompanied by clear mandates and guidelines about how these changes will impact the pre-existing service provision as well as the customer–company relationship. In case of a major overhaul in the system and relationship, it becomes necessary that adequate steps are taken to ensure that these changes are clearly communicated to the consumers. This needs to be accompanied by a set of instructions about best practices and the code of conduct to be followed by either party, and a proper redressal mechanism.

For example, a leading social media firm that has ventured into the metaverse rolled out notifications letting people know about its updated privacy policy, which explains how it collects, uses, shares, retains and transfers information.³⁵ It is also investing in controls that allow users to manage and report problematic content and conduct as well as safety tooling designed for immersive experiences.

As financial services players look at deploying solutions through new-age technologies like the metaverse, they will need to incorporate the implications of these new modes of interaction with the end consumers into their policies, terms and conditions. Furthermore, there will be a need for clear regulatory guidelines on the roles and responsibilities of the financial services and technology players with respect to consumer data ownership, service level agreements and complaint redressals.

With the constant growth of the financial services sector and increasing use of emerging technologies, policymakers and regulators would continue to play a predominant role in this space. They would act as enablers that safeguard the interests of the customers and the fundamentals of the industry. Moreover, regulators and policymakers would need to study and understand the implications of these new technologies in the context of financial services in order to update and evolve regulations and guidelines regularly.

34. <https://www.fintechfestival.sg/global-fintech-hackcelerator/>

35. <https://indianexpress.com/article/technology/social/meta-reveals-new-privacy-policy-to-come-into-effect-from-july-26-7938843/>

06

Way forward

As the financial services sector continues to see innovations, disruptions, competition, and a growing increase in consumer awareness and demand, banks and FinTechs need to gain a competitive edge by looking at the next wave of technologies and weigh their advantages.

With the exponential growth of the Indian FinTech ecosystem, financial institutions will have a chance to innovate, collaborate and transform the ecosystem for inclusive economic growth. With the increased focus on security, transparency, decentralisation and trust, financial services players will be able to develop these new ways of operating and interacting through the potential that the new emerging technologies provide.

While these technologies have already seen growing traction and adoption, there are significant roles that governments, regulators and policymakers can play to help these technologies flourish. There has already been some movement in this regard. India is set to invest USD 1 billion to enhance its capabilities in quantum computing.³⁶ The Government has initiated blockchain-based projects for certification, Goods and Service Tax (GST), public distribution system (PDS), etc.³⁷ The Ministry of Electronics and Information Technology has chalked out a national strategy on Web 3.0,³⁸ and the RBI is set to launch the CBDC.³⁹

As the use of emerging technologies becomes more prominent and policy and regulations are standardised, an inclusive, tech-driven ecosystem would help nurture the growth of the existing financial services landscape and FinTechs through policy-level support and public-private partnerships. When there is greater synergy between policy enforcement support and appropriate use of emerging technologies in FinTechs, it will be easier to achieve greater financial growth and inclusion.

36. <https://www.computerweekly.com/news/252513355/India-to-invest-1bn-in-quantum-computing>

37. <https://blockchain.gov.in/projects.html>

38. <https://www.businessworld.in/article/MeitY-Releases-National-Strategy-On-Blockchain-For-Its-Adoption-In-Govt-Systems/04-12-2021-413777/>

39. <https://indbiz.gov.in/indea-2-0-redefines-govtech-for-web-3-0/>



About the Fintech Convergence Council (FCC)

The FCC was started in 2017 as a FinTech committee and converted into a council with its governing board in 2018. With 70+ members, the FCC represents various players in the FinTech, banking, financial services and technology space. It aims to be a platform for the financial services ecosystem to deliberate, integrate and lead the development of FinTechs. The council proactively works towards the growth of FinTechs and penetration of financial services to support its national goal of financial inclusion, moving towards a digitally empowered country. Its mission is to identify and build opportunities for collaboration, facilitate convergence between the various players in the financial services domain and to grow and drive market expansion.

For more information, visit: <https://www.fintechcouncil.in/>

About the Payments Council of India (PCI)

The Payments Council of India (PCI) is a body representing over 85% of the non-bank companies in the payments ecosystem to effectively cater to the needs of the digital payments industry. The objective of PCI is to identify and build opportunities, and address and help resolve industry-level issues and barriers which require industry-level discussion and action, and proactively encourage the growth of non-banking payment systems for ushering in a 'less cash society' in India. While public policy and regulatory affairs are the primary focus areas of the PCI, the council also advocates the preparation of several reports and whitepapers and hosts roundtables and residential immersion programmes for the overall development of the payments industry. The council works with all its members to promote the growth of the payments industry and scale the vision of the payments ecosystem in India.

For more information, visit: <https://paymentscouncil.in/>

About the National Payment Corporation of India (NPCI)

The National Payments Corporation of India was incorporated in 2008 as an umbrella organisation for operating retail payments and settlement systems in India. The NPCI has created a robust payment and settlement infrastructure in the country through a bouquet of retail payment products such as RuPay card, Immediate Payment Service (IMPS), Unified Payments Interface (UPI), Bharat Interface for Money (BHIM), Aadhaar, National Electronic Toll Collection (NETC) FASTag and Bharat BillPay. The NPCI is focused on bringing innovations in the retail payment systems through the use of technologies and is relentlessly working to transform India into a digital economy by facilitating secure payments solutions with nationwide accessibility at minimal cost.

For more information, visit: <https://www.ncpi.org.in/>

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