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STRIDES - A STUDENTS' JOURNAL OF SHRI RAM COLLEGE OF COMMERCE
ISSN 2581-4931 (Print)

Shri Ram College of Commerce is well known for its academic excellence and dedicated approach towards dissemination of knowledge in the academic world. The college appreciates the role of research in education and is committed to developing an inclination towards research in both faculty and students. In this pursuit, the college has taken the initiative to launch a new Journal named 'Strides - A Students' Journal of Shri Ram College of Commerce'.

ABOUT THE JOURNAL

It is a double blind reviewed bi-annual Journal launched exclusively to encourage students to pursue research on the contemporary topics and issues in the area of commerce, economics, management, governance, polices etc. The journal provides an opportunity to the students and faculty of Shri Ram College of Commerce to publish their academic research work.

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Shri Ram College of Commerce is committed to upholding the high academic standards. Therefore, the Committee on Publication Ethics (COPE) follows a 3-Stage Selection Process while approving a paper for publication in this Journal. The policy is as follows:

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The research paper is to be typed on A-4 size paper with single line spacing. The complete length of the paper should not exceed 5000 words including endnotes and references. The font size should be 12 and font style should be Times New Roman.

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Endnotes should be serially arranged at the end of the article well before the references and after conclusion.

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The first letter of the caption for table, figure, graph, diagram, picture etc. should be in capital letter and the other words should be in small letter - e.g. Table-1: Demographic Data of Delhi, Figure-1: Pictorial Presentation of Population etc.

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Declaration

As part of the submission process, the student and mentor needs to declare that they are submitting original work for first publication in the Journal and that their work is not being considered for publication elsewhere and has not already been published elsewhere. Again, the paper should not have been presented in any seminar or conference. The scanned copy of duly signed declaration by the students and their respective mentors has to be emailed along with the research paper.

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Principal's Message

To achieve and promote excellence in research and publish quality academic as well as educational resources as guided by the Mission Statement of the College, Shri Ram College of Commerce had launched a Journal, "Strides- A Students' Journal of Shri Ram College of Commerce" on the occasion of 91st Annual Day of the College held on 13th April, 2017. The Journal was released by then the Hon'ble Union Minister of Human Resource Development, Shri Prakash Javadekar. The Journal publishes the research papers and articles written by students of the College under the mentorship of Faculty Members which go through an intense review mechanism before getting published.

Through the Journal, students get an excellent platform to enhance their research calibre, display their academic perspective, and practically apply their classroom learnings to real-world situations. The present Issue includes several multi-disciplinary and contemporary topics such as "Quantum computing: A futuristic frontier in the financial sector", "Unfolding the Global Hunger Index 2020", "Role of Monetary and Fiscal policies during Covid-19: India and Comparative Analysis", "An analysis of macroeconomic and bank-specific causes for burgeoning NPAs in India", "The political leaning paradox", and "Re-engineering climate change solutions through carbon credit trading".

I wholeheartedly congratulate the Editor, Strides, Dr. Rajeev Kumar and students whose research papers got published in Volume 4 Issue 1 & 2 of the Journal. Simultaneously, I encourage more students to contribute their research papers for the successive Issues.

My best wishes for your future endeavours!

Prof. Simrit Kaur
Principal

Editor's Message

Shri Ram College of Commerce is well known for its academic excellence and dedicated approach towards dissemination of knowledge in the academic world. The College acknowledges and values the role of research in education and is firmly committed to develop and encourage an inclination towards research in both faculty and students. To reaffirm this ethos, the College has taken the initiative to launch a new Journal named 'Strides - A Students' Journal of Shri Ram College of Commerce' to encourage students to pursue research under the guidance of the faculty of Shri Ram College of Commerce.

It is a bi-annual Journal launched exclusively to publish academic research papers and articles by the students on contemporary topics and issues in the area of commerce, economics, management, governance, policies etc.

In order to maintain high standards of publication, COPE (Committee on Publication Ethics) has been constituted. The COPE is the apex authority which authorises over all the decisions related to publication of research papers and articles in Strides. The recommendations and decision of COPE is final and binding.

To maintain high academic standards, academic ethics and academic integrity, a rigorous process of double-blind review of research papers is followed along with screening of plagiarism of each manuscript received by the COPE for publication. The research work published in Strides is absolutely original and not published or presented in any form at any other public forum.

The foundation issue of the Journal "Strides - A Students' Journal of Shri Ram College of Commerce, Volume 1, Issue 1, 2016-17" was successfully released on 91st Annual Day of SRCC held on 13th April, 2017 by Shri Prakash Javadekar, Honb'le Union Minister of Human Resource Development, Government of India. The successive issues of 'Strides - A Students' Journal of Shri Ram College of Commerce' have been released bi-annually. However, due to the COVID19 pandemic and ensuing lockdowns the current issue has been delayed.

I congratulate all the students whose research papers are published in this issue of Strides and express my sincere thanks to their mentors and referees.

Dr. Rajeev Kumar
Editor

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STRIDES - A STUDENTS' JOURNAL OF SHRI RAM COLLEGE OF COMMERCE

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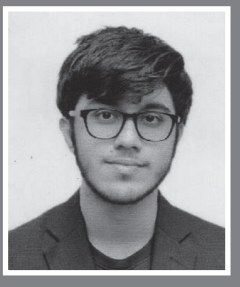
RESEARCH PAPERS

Quantum Computing: A Futuristic Frontier in the Financial Sector



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ABSTRACT

Quantum Computing is an emerging and disruptive technology impacting various sectors of the economy including finance. Unlike the present computers which work on bits that exist as either 0 or 1, quantum computers encode information as quantum bits that exist as a superimposition beyond those two states. This feature makes it way more powerful than today's supercomputers. In this context, the present paper discusses the concept of quantum computers, its extraordinary features that differentiate it from classical computers and examines the futuristic applications of quantum computing in various spheres of the financial sector such as banking, insurance, stock markets, and cryptocurrency. A comprehensive analysis is conducted to put forward several dimensions ranging from operational and routine applications such as fraud detection, data handling and processing, and risk profiling to advanced and sophisticated functions such as targeted prediction, Monte Carlo optimization, quantum bitcoin, trading optimization, and pricing of financial derivatives.

Additionally, a cross-country analysis is carried out with respect to their allocations and achievements towards Quantum Computing with a special focus on India's progress in this field. Quantum Computing is still at its nascent stage but has a promising role to play in the field of finance.

INTRODUCTION

With each passing day, millions of people around the globe are working tirelessly to enhance the fourth industrial revolution. It is a phase where all the boundaries between the physical, digital, and biological worlds become blurred. One of the elements that is believed to be crucial in bringing forth the true potential of the fourth revolution is Quantum Computing. In the 80s, scientists started considering numerical calculations from an entirely different perspective: using the intrinsic, quantum mechanical properties of matter to solve problems (Neilson and Chuang, 2002). This marked the conceptual birth of Quantum Computing. However, the true realization of quantum computing technology lies much ahead in the future and it is very evident that the first-mover advantages in this field will provide benefits in the long run. Therefore, several countries, both developed and developing are investing exorbitant amounts towards researching and developing quantum technology. Moreover, varied multi-national companies such as Google and Alibaba have set up separate research bases to try and unleash the technology's potential.

Quantum Computing has everlasting implications for all types of industries ranging from aerospace to health care and pharmaceuticals. Since money and finance remains at the core of most sectors in the economy, the quantum computer's true potential lies at the centre of the financial industry. Let us first discuss the difference between classical and quantum computers to understand the applications of Quantum Computing. The component which is at the core of a classical computer is a processor. The processor is made up of numerous small components called transistors. A computer is made of billions and trillions of transistors and they play the indispensable role of a switch to stop and facilitates flow of electricity. Historically, the size of the transistor has been reducing over the years leading to twin benefits of increased computing power and less energy consumption leading to better

efficiency. Currently, the scale of transistors lies between 10-20 nanometres and is expected to further shrink in the coming years. Consequently, the size of the transistors is believed to mirror the size of an atom. At this stage owing to a concept known as quantum tunnelling, the transistor will become incapable of doing what it was essentially made for that is stopping and letting electrons (electricity) pass. This will become an unsolvable problem for classical computing. Thus, comes the role of quantum computing into the picture which not only overcomes the above-mentioned problem but uses it to its advantage. In classical computers, bits are the smallest units of information and are represented by 0 (low charge) and 1 (high charge). Quantum computers use qubits whose value is entirely probabilistic and can be in any proportions of 0 &1 (known as superposition). This results in an exponential increase in its power as a qubit can function both like 0 or 1 bit. Four classical bits can be in sixteen (24 = 16) different configurations out of which only one can be used at a time. Four qubits in superposition, however, can be in all of those 16 combinations at once. This number of combinations increases exponentially by simply adding more qubits. For example, only 20 qubits can store a million values in parallel. Quantum entanglement is another feature through which actions performed on one qubit affects another entangled qubit no matter how far apart they are. Hence, a quantum computer sets up some qubits, applies quantum gates to entangle them and manipulate probabilities, then finally measures the outcome, collapsing superpositions to an actual sequence of 0s and 1s. This implies that unlike a classical computer, we can get the entire lot of calculations that are possible with the setup, all done at the same time.

This will increase the efficiency and effectiveness of data classification, IT security, simulations and machine learning. Table 1 showcases the Quantum Computing developments over the years.After the brief introduction in Section 1, Section 2, provides a detailed explanation of varied applications of quantum computing in financial sector. In Section 3, we examine the quantum efforts made by countries worldwide with a deeper focus on India. Finally, in Section 4, we conclude and discuss the policy implications

Table 1: Timeline of developments of Quantum Computing

May 1981	Richard Feynman proposed the idea of quantum phenomena to perform calculations. In a speech at the First Conference on the Physics of Computation at MIT, he suggested a simple method for a quantum computer.
March 1984	At the university of Oxford, David Deutsch wrote a paper which gave a description of a first ever universal quantum computer and suggested similarity in operation of logic gates in both quantum and traditional computers.
March 1994	In New Jersey, Peter Shor discovered what is known as Shor's algorithm. This algorithm allows a quantum computer to give factors of a large integer very quickly, and could hence break various cryptosystems used today.
Jan 1996	Lov Grover discovered what is known as the Grover's algorithm. This algorithm allows a quantum computer to search an unsorted database at a much way faster speed than a classical computer.
May 1998	First 3-qubit Quantum Computer built by scientists at MIT and the University of Waterloo
August 2000	First 5-qubit Quantum Computer built by IBM on which Shor's algorithm was also partly demonstrated
November 2000	First 7-qubit Quantum Computer built at Las Alamos National Laboratory in New Mexico
December 2001	IBM fully executed Shor's Algorithm with a 7 qubits computer. The Seven-qubit machine found the factors of the number 15. Although the answer may appear to be trivial it was the most complex quantum computation performed till then.
December 2005	The first qubyte was created at the University of Innsbruck in Austria. An entanglement of eight quantum was observed, yielding a qubyte.
May 2006	First 12-qubit Quantum Computer built at Institute for Quantum Computing, Perimeter Institute for Theoretical Physics and MIT. The team's inferences set a new algorithmic benchmark to utilize quantum properties I order to support entirely new modes of information processing.
November 2007	World's first 28 qubit Quantum Computer demonstrated online at Supercomputing 2007 conference by D wave
June 2009	Yale university created solid state quantum processor. It was an achievement because before this scientist didn't manage to get a qubit to last longer than a nanosecond, but the Yale qubit lasted a microsecond.
June 2011	D-wave company announces a 10-million-dollar commercial quantum computer with a 128-qubit chipset that performs task known as discrete optimization. However, scientists worldwide have criticized the same because of lack of demonstrations.
March 2012	Caltech physicist John Preskill describes the moment when "well-controlled quantum systems can perform tasks surpassing what can be done in the classical world" as the arrival of "quantum supremacy"
November 2017	IBM reveals its working prototype of 50 qubits Quantum Computer which was earlier considered to be the threshold of 'Quantum Supremacy'.
October 2019	Google claims the achievement of 'quantum supremacy'. The company claimed the quantum processor Sycamore was able to perform a specific task in 200 seconds that would take the world's best supercomputer 10,000 years to complete however remains contradicted by IBM

Source: Time toast, 2020

Application of Quantum Computing in Finance

Quantum algorithms hold the potential to provide prodigious speedups to the way several activities are carried out today in the financial world. This speedup is known as quantum speedup and can be used to improve and

carry out various algorithms that were not possible on traditional computers. In this section, we throw some light on the problems faced by the financial sector and how Quantum Computing technology can help to overcome them. We have divided our discussions into four components of financial sectors namely, Banking, Insurance, Financial Markets, and Cryptocurrency.

Banking and Insurance

One of the most important roles that banks and insurance companies as intermediaries play is that of customer data storage and handling in order to optimize the user experience. However secondary the task of data management for a large-scale bank may seem, it is very hard and requires sophisticated technology. This can be illustrated by data breach events of Bank of America in 2005 with 12,00,000 records compromised, Compass Bank in 2007 with 10,00,000 records leaked, European Central Bank in 2014, and the list goes on. The same was witnessed in India as well. In 2016, major banks including SBI, HDFC Bank, ICICI, Yes Bank and Axis Bank witnessed a gigantic data breach with over 3.2 million debit cards used for foul-play. According to research conducted by Juniper Research, over 146 billion records are expected to be lost to cybercriminal attacks between 2018-2023 worldwide.

Therefore, the world's largest banks including Barclays and JP Morgan chase are shifting their outlook towards quantum computing for strengthening the security of databases with key customer and transaction details. Better data management helps such institutions withstand periods of vulnerability and financial crashes as well (Trehan, 2019). In the realm of quantum computing, the concept of quantum encryption is set to play a major role in data protection in the coming years. Quantum encryption sends data over quantum networks and uses a set of the system known as Quantum Key Distribution (QKD). QKD ensures encrypted messages and their keys are sent separately and if either of them gets tampered during transmission, they both get destroyed automatically. Combining quantum encryption with blockchain technology will create arguably the most hack-proof technology in the Internet of Things (IoT) era.

Quantum computing because of its sheer dominance in processing information also presents a once in a lifetime opportunity for banks and

insurance companies in terms of transaction speed. With an all-time surge in internet penetration rate due to Covid (currently 59% worldwide) and pro-active efforts of the government around the world to strengthen the banking system, it is apt to mention that the number of unbanked adults (1.7 billion) is set to go down in the future. This in turn would lead to more transaction traffic for banks. Quantum computer's ability to handle billions of transactions per second will help banks meet that traffic more efficiently than present-day technology. Just like Quantum Encryption combined with blockchain present the opportunity for hack-proof transmission, Quantum Computing powered by Artificial Intelligence (AI) will help banks and insurance companies automate decision making to a large extent. Therein ridding the banks of many operational technicalities like approval of bank mortgages and loans, project profitability measurement, better-consulting services for clients, etc. (Cag, 2020).

Artificial intelligence and Machine Learning are finding their way into majorly all spheres of life with greater acceptance. This is illustrated by its heavy influence in services provided by Siri, Alexa, Netflix, Pandora, Amazon.com, Tesla, etc. Google's current CEO once stated that AI and Quantum Computing are best placed to shape the tech industry in the years to come. We are all familiar with the ability of Quantum Computing to process enormous chunks of information in a short time. This ability can provide artificial intelligence machines with the feedback required for them to improve their performance, and subsequently, shorten their learning curve (bobsguide, 2018). However, the error rate is very high relative to current technology standards and will have to be improved drastically to impressively harness quantum computers. This ability of quantum computers to process large quantities of data means that they would provide artificial intelligence machines with the feedback required for them to improve their performance, and subsequently, shorten their learning curve (bobsguide, 2018). Mentioned below are some ways through which Quantum AI will empower banks and insurance companies:

Personal Assistants and Chatbots: In the times to come, Chatbot is expected to become a force to be reckoned with. Chatbots can save up to 30% in Customer Support Costs and 90% of the banks' interactions are expected by customers to undergo some sort of Chatbot automation by the end of 2022

(Chatbot Magazine, 2017). Quantum AI has the ability to undertake at the same time billions of personalized conversations recommending billions of personalized products, thus providing far superior customer service and cost reduction.

Mobile Banking and Personalised planning: Nowadays people especially millennial rely heavily on the internet to manage their finances. Quantum AI can meet the user's needs with great precision using personal, contextual, and predictive services and thus provide a great advantage over banks.

Automated Recruiting: We have seen how recruiting has also come under the ambit of AI and how companies like Unilever, PwC, Vodafone, and Oracle have used the same. Adding quantum computing to the mix will open a plethora of opportunities in terms of more sophisticated criteria setting, better body language judgement, better internal skills inventory management and much more.

Big Data Analytics: Big data analytics is also being increasingly used in various fields like hospitality, government and public sector services, energy, education, etc. Talking specifically about banking and insurance, big data combined with quantum computing will speed up transactional activities and grouping of seemingly incongruent assets. Getting even more specific, Quantum Big Data Analytics will prosper in segments discussed next:

Efficient Profiling of customers: Customer segmentation helps banks to classify their customers by demography. However, it does not possess the granularity to enable them gain meaningful information regarding their needs and wants. Using big data and quantum computers, banks and insurance companies will get the relevant data for billions of customers such as the customer's demographic information, number of accounts and products they have, offers they've declined in the past, products they're likely to purchase in the future, major life events, their relationship with other customers, attitude toward their bank and the financial services industry as a whole, behavioural patterns and service preferences.

Opportunities for upselling and cross-selling: Businesses are 60%-70% more likely to sell to existing customers than they are to prospective customers.

This translates to great opportunities for upselling and cross-selling using quantum big data analytics. For example, if some bank in collaboration with Indigo launches credit cards on attractive terms for Air travel, it would have been challenging to first create a database of prospective customers and then marketing the same. However, with quantum big data tools, no matter whatever be the size of customer information, it will be easier for employees to spot favourable user tickets on which marketing techniques can be built.

Fraud Detection: There have been 650572 cases of identity threats alone in the US in 2019 (The Ascent, 2020) of which around 40% are credit card thefts. Along with this insurance frauds are also on the rise. It is discovered that out of 10 billion global online transactions from September 2018 to September 2019, 9.14% were found to be risky in the insurance industry compared to 5.09% across all industries (Insurance Post, 2020). Estimates show that financial institutions are losing between USD 10 billion and 40 billion in revenue a year due to fraud and poor data management practices. Fraud detection systems are highly inaccurate showing 80% false positives, causing financial institutions to be highly risk-averse. If proper credit scoring needs to be done, it can take as long as 12 weeks, for which most of the customers may not be willing. (IBM, 2020). Quantum computers can support highly effective pattern recognition algorithms, helping to detect even more sophisticated acts of fraud. This way, it can result in large cost reductions, prevent companies from losing genuine customers, and support the IT infrastructure of these institutions (Ben Rossi, 2016).

Workplace Improvements: We live in a time where employer branding is given a lot of importance by the employee supply in the market which has in turn been magnified by the pandemic. So, it has become increasingly important for banks and insurance companies to look after employee needs at all levels as in Maslow's Need Hierarchy Theory. Big data analytics powered by Quantum Computing will help said companies maintain even hourly data of performance metrics, assess employee feedback, work culture trends, and possible future conflicts.

Stock Markets

Quantum computing's specific use cases for stock markets can be classified into three main categories: targeting and prediction, trading optimization, and risk profiling discussed hereby.

Targeting and Prediction: As the number of firms providing financial services is increasing, their customers are also demanding more personalized products and services that can rapidly anticipate their evolving needs and behaviours. 25% of small and medium-sized financial institutions lose their customers because of failure to provide services up to the customer's satisfaction. The task of creating analytical models that can sift through mounds of behavioural data quickly and accurately is near to impossible with traditional computers. Quantum computing can be a game-changer for customer targeting and prediction modelling. For instance, in 2019, Google was believed to achieve 'quantum supremacy' with its Sycamore Quantum processor for solving a calculation in 3 minutes 20 seconds that would have otherwise taken approx. 10000 years if done by a supercomputer. (The Financial Times, 2019).

Trading Optimization: Financial markets are known is their complexity. Every investor seeks to maximize his returns on his investments, but there are millions of combinations possible in making a portfolio, making it impossible for the traditional technology to decipher the best combination of assets and their weights due to the computational limitations and transaction costs. For example, Multiverse Computing, a startup working on Quantum computing technology over the course of a year, tried to find the most profitable mix from a group of 50 assets, subject to restrictions, such as how often trades could be made. The result was a problem with around a whopping 101,300 possible solutions (The Economist, 2020). Quantum computers along with the market volatility can take into account customer life-event changes, into portfolio optimization. This technology has the potential to cut through the challenge of complexity and help the financial service providers in portfolio diversification, rebalance the portfolio considering the market changes and reduce the cost of the trade settlement process.

Risk Profiling: Financial service institutions are regularly asked to improve their present methods of balancing risk, hedging positions, and perform a wider range of stress tests to comply with regulatory requirements. Liquidity management, derivatives pricing, and risk measurement can be complex to calculate. Quantum computers can quickly solve problems that are encountered in algorithmic trading with speeds that are increasing exponentially, rather than linearly. For instance, IBM developed a quantum

algorithm that can estimate the risk of portfolios of financial derivatives. Classical Monte Carlo needs millions of samples to get a reasonable accuracy, whereas, with the quantum algorithm, risk can be reduced significantly.

Monte Carlo Quantum Methods: While using Monte Carlo methods, the required number of simulations become very large if the purpose is to obtain the most probable outcome. However, combining the Quantum algorithm with the Monte Carlo method can give a near quadratic (or power 2) quantum speedup over classical algorithms (Montanaro, 2015) even in stock market simulations.

Pricing of Financial Derivatives: The payoff in financial derivatives contracts depends on the future price paths of some underlying asset. Brokers must know what should be the fair price value of the derivatives on the basis of the state of the market. This is a pricing problem, which can be solved with Monte Carlo simulations. But the growing number of derivatives have resulted in high computational cost and lengthy execution times. A quantum Monte Carlo simulation can tackle this problem effectively (Quantum World Association, 2018).

Crypto currency

Bitcoins are accorded as one of the safest and highly encrypted form of money storage. That is the biggest reason for them being so expensive. But quantum technology provides a possibility to take control over this blockchain technology. Theoretically, a 4,000 qubit quantum computer could crack bitcoin and most of the other crypto currency's encryption in a matter of seconds, whereas even a super computer might take 1000s of years to do the same. (Robert Stevens, 2020). One can possibly credit their account with free bitcoins or prevent someone from making transactions. Hackers can derive the private key used to sign transactions from the public keys exposed during transactions. The vulnerability that the cryptosystem is surfaced to is due to shortcomings such as Exposed Public Key (Anastasia Marchenkova, 2019), reusable wallet addresses, fast enough attack, and possibility of Lost Coins (Anderson, 2017). However, quantum bitcoins can offer various advantages such as faster transactions, high scalability, anonymity, free

transactions and better predictability (Jogenfors, 2019).

CROSS-COUNTRY DEVELOPMENTS IN QUANTUM COMPUTING

Quantum computing is all set to revolutionize the world and become the face of tomorrow's technology. The following countries have illustrated the same by initiating humongous and innumerable projects over the last few decades to better position themselves in this upcoming disruptive wave as depicted by figure 1 below:

Figure 1: Worldwide Allocations in QC

(*Summary of world programs' outlay towards building Quantum Technology in the past decade ($ million))*

U.S. has always been at the top of the race of developing Quantum Computing technology. One of the major reasons being contribution from its "Big Tech" companies, i.e., Google, IBM, and Microsoft, which are making significant efforts to develop this technology. In 2018, IBM secured more patents than any other US company (most of the patents being in the field of artificial intelligence, quantum computing, and blockchain). Google recently achieved quantum supremacy, solving a problem in 200 seconds which would have taken 10,000 years for a classical computer to solve. Microsoft has developed Q#, an open-source programming language, which they will use

to develop and run quantum algorithms (Inria, 2020). In December 2018, U.S. Former President Trump signed H.R. 6227, to fund a bipartisan act, i.e., the National Quantum Initiative Act (NQI). Research and development in quantum technology were made a national priority. Through this law, the government has dedicated $1.2 billion towards the development of quantum information processing over the course of a decade.

China is not far behind in this race to the U.S. The country on its way to trying to become the world's new superpower has shifted its focus extensively towards quantum computing. China made quantum technology a key priority in its 13th five-year plan (2016-2020) and the Made in China 2025 plan. In 2017, China announced to build a 92-acre National Laboratory, costing $10 billion for quantum information sciences. When executed, it would be the world's largest quantum laboratory. This center has a huge potential to become a global hub for quantum research and a hotspot for future quantum research talent. Like the U.S, Chinese tech giants are also investing a lot of R&D in this field. In, 2015, Alibaba set up its own QC laboratory to produce a 50 to 100 qubit quantum prototype by 2030. It has also invested $15 billion in artificial intelligence, FinTech, and quantum research. Meanwhile, Baidu in March 2018 announced the creation of a quantum computing institute, and in the same year, Tencent established the Tencent Quantum Lab for scientific research in quantum computing (Inria, 2020).

Canada has invested roughly a sum of $1 Billion dollars over the past decade and is characterized by a growing private sector, exemplary research expertise, and immense government support to innovations. Canada was also ranked fifth in annual quantum research spending according to a survey (The Economist, 2017). Several institutions in Netherlands are leaders in fields like quantum Internet, quantum algorithms, and post-quantum cryptography. A total commitment of around $150 million has been made towards QuTech, quantum technology of TU Delft (Delft University of Technology) and TNO (Netherlands Organisation for Applied Scientific Research) (CISRO, 2019).

In Russia, quantum research is supported by both the government and industrial entities. The Russian government in 2019 invested around $663

million for the next five years into basic and applied quantum research carried out at leading Russian Laboratories with a focus on Quantum Computing and Quantum Simulation, Quantum communications, Quantum metrology, and sensing and enabling technologies (Nature, 2019). In South Korea, investments of $39.7m and $11.9m are made for developing core QuTechnology and research base over 5 years and ultra-high-performance computing knowledge data, convergence, system software, software engineering, information, and intelligence systems, and HCI (Human-Computer Interaction). In Japan, the total investment made in Quantum science and technology is around $280 million and has been made by players like Japan Science and Technology Agency, the Cabinet Office of the Government of Japan, etc. (Yamamoto, Sasaki and Tekesue, 2019). For example, the Japanese Govt. launched the Q-Leap in 2018 to invest in quantum simulation and computation, quantum sensing and Ultrashort pulse lasers. The Moonshot project is expected to invest around ¥15-20 to create a fault-tolerant universal quantum computer by 2050.

Australia has invested AU$130 million through federal funding and state-level investments in QuTech Development. (IOPScience, 2019) In 2017, two new quantum-focused Centres of Excellence were established as five-year programs: The first centre is FLEET (Future Low-Energy Electronics Technologies) located in Monash University and the second centre is Exciton Science located in the University of Melbourne.

Singapore in 2007 developed a Centre for Quantum Technology that enlists physicists, computer scientists, and engineers to conduct elementary research on quantum physics and to build devices based on quantum phenomena (Techinasia, 2019) Since then 2000 scientific papers have been published, researchers have won S$40 million in grants and established start-up companies and over 60 students have trained PHDs in QuTech. The overall quantum expenditure done in the past 5 years in the country is about S$150 million. The European Commission allocated €1b of funding over 10 years to launch the European Quantum Flagship in 2018 with the main aim to consolidate and expand European scientific leadership and excellence in this research area in order to kick-start a European industry in quantum technology. France has been investing 60m € in quantum technologies every year. The French government in 2020 launched a plan to structure a national

strategy for quantum technologies and estimated they would require 1.4b € over the next five years to fund quantum research. The strategic recommendations included creating an effective environment for innovation, delivering a tailored economic security strategy and establishing effective governance. In January 2021, French President Emmanuel Macron announced a five-year investment plan worth $2.2b in quantum technologies (Lemonde, 2021).

Indian Context:

In India, the Indian Institute of Science has a dedicated research area for quantum technology. It explores many areas like superconducting qubit devices, single-photon sources and detectors for quantum communications, integrated photonic quantum networks, and quantum sensors (Indian Institute of Science, 2020). In 2020, Indian government introduced an NM-QTA (National Mission on Quantum Technologies and Applications) with a total budget of INR 8000 crores (approximately $1b) over a five-year period. The top institutes that are currently offering education on Quantum Mechanics in India are, Tata Institute of Fundamental Research (TIFR); the International Center of Theoretical Sciences (ICTS); IISER Pune; IISc, and IIT Kanpur (Misal, 2018). From a national security perspective, there are 2 threads for global efforts. First, to build a quantum computer capable of decrypting secrets of other countries. Second, to build one's own communication hack proof and secure from the upcoming quantum technology. The ministry of Electronics and IT is interested in computing aspects; Defence Research and Development Organization (DRDO) in encryption products and, ISRO in satellite communication.

All these initiatives may sound good in isolation, but when compared with other countries, India lags far behind in the Y2Q ("years to quantum") race. But what are the reasons behind this state of being? First, India doesn't have a considerable number of workforce engaged in the field of quantum technology i.e., only around 100-200 researchers. A lot of Indians who are engaged in this field are working abroad in the companies like IBM and Google. Secondly, there's a lack of coordinated efforts. There are many researchers working in isolated communities on various aspects: quantum hardware, quantum key distribution, information theory, and other fields. The

complexity of this technology demands many kinds of expertise under one roof instead of the minimal communication that is currently happening amongst them. Third, India being strong on theory but weak on hardware. According to experts, lack of research is not the impediment to prepare for a quantum future, but the lack of infrastructure to carry that research out is. However, Indian Government has also identified this gap and is working towards it. Finally, where the private sector and big corporates are playing a major role in Quantum technology development in other countries, India's private sector and investors have not yet initiated efforts. Till date, the progress has been made only by the Government, but there is a need for big players like Wipro and Infosys to step in (Bansal, 2020).

CONCLUSION

The present paper elaborates the role of quantum computing in the area of finance. It is developing at a striking rate due to numerous leaps taken in its hardware development and in expansion of its conceptual theory. Unlike the present computers which work on bits that exist as either 0 or 1, quantum computers encode information as quantum bits that exist as a superimposition beyond those two states. This feature makes it way more powerful than today's supercomputers.

In this context, the present paper discusses the concept of quantum computers, its extraordinary features that differentiate it from classical computers and examines the futuristic applications of quantum computing in various spheres of the financial sector such as banking, insurance, stock markets, and cryptocurrency. A comprehensive analysis is conducted to put forward several dimensions ranging from operational and routine applications such as fraud detection, data handling and processing, and risk profiling to advanced and sophisticated functions such as targeted prediction, Monte Carlo optimization, quantum bitcoin, trading optimization, and pricing of financial derivatives. Additionally, a cross-country analysis is carried out with respect to their allocations and achievements towards Quantum Computing with a special focus on India's progress in this field. Several countries are performing outstandingly in this race of reaching quantum supremacy including India. It is certain that financial sector would be one of the biggest beneficiaries when quantum computers reach the

expected level of growth. But to fully harness the power of QC a lot needs to be done. There is an urgent need to increase the quality of the qubits and identify a reliable means to control and perform various sophisticated activities as described in the paper. Environmental factors (such as air, noise, and heat) also are a cause of concern for the qubits to maintain the superposition that is delicate and fragile (Philip Ball, 2018). Hopefully the challenges would be addressed in years to come demonstrating a promising role of QC in the field of finance.

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STRIDES - A STUDENTS' JOURNAL OF SHRI RAM COLLEGE OF COMMERCE
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HISTORY OF THE JOURNAL

The idea to launch this Journal was discussed in December 2016 by the former Officiating Principal, **Dr. R. P. Rustagi** with **Dr. Santosh Kumari,** the Editor of the Journal. Since the idea appealed to **Dr. Santosh Kumari**, she took the initiative to contribute to SRCC by creating this new academic research Journal and took the responsibility for its Creation, Registration, License and ISSN (International Standard Serial Number) etc. along with *Editorship*. Therefore, **Dr. Santosh Kumari, Assistant Professor in the Department of Commerce, Shri Ram College of Commerce** was appointed as the Editor of the Journal vide. Office Order – SRCC/AD-158/2017 dated March 14, 2017. She meticulously worked hard in creating the concept and developing the structure of the Journal. She introduced the concept of COPE (Committee On Publication Ethics) to maintain the high academic standards of publication.

On behalf of SRCC, **Dr. Santosh Kumari** made every effort in seeking License from Deputy Commissioner of Police (Licensing), Delhi to register the Journal at "The Registrar of Newspapers for India, Ministry of Information and Broadcasting, Government of India". The paper work for seeking license started under the former Officiating Principal, **Dr. R.P. Rustagi** on March 27, 2017. The foundation Issue of the Journal "**Strides – A Students' Journal of Shri Ram College of Commerce, Volume 1, Issue 1, 2016-17**" was successfully released on the 91st Annual Day of SRCC held on April 13, 2017 by **Shri Prakash Javadekar, Honb'le Union Minister of Human Resource Development, Government of India**. The title of the Journal got verified and approved by the Registrar of Newspapers for India, Ministry of Information and Broadcasting, Government of India on April 21, 2017. On September 1, 2017, **Prof. Simrit Kaur** joined SRCC as Principal and signed each and every legal document required for further processing and supported **Dr. Santosh Kumari**.

On December 18, 2017, the College got the license "**License No. - DCP / LIC No. F. 2 (S / 37) Press / 2017"** to publish 'Strides – A Students' Journal of Shri Ram College of Commerce'. Due to change of Printing Press, the License got updated on March 09, 2018. On April 26, 2018, the SRCC Staff Council unanimously appointed **Dr. Santosh Kumari as the 'Editor of Strides**' for the next two academic years.

On April 27, 2018 (The Foundation Day of the College), **Dr. Santosh Kumari** submitted the application for the registration of the Journal. On May 04, 2018, the SRCC received the '**Certificate of Registration**' for **"*Strides – A Students' Journal of Shri Ram College of Commerce*"** and got the **Registration No. DELENG/2018/75093** dated May 04, 2018. ***On behalf of Shri Ram College of Commerce, it was a moment of pride for Dr. Santosh Kumari to receive the 'Certificate of Registration' on May 04, 2018 at the Office of Registrar of Newspapers for India, Ministry of Information and Broadcasting, Government of India (website - www.rni.nic.in).***

On May 07, 2018, **Dr. Santosh Kumari** submitted the application for seeking ISSN (International Standard Serial Number) at "ISSN National Centre – India, National Science Library, NISCAIR (National Institute of Science Communication and Information Resources). Weblink - http://nsl.niscair.res.in/ISSNPROCESS/issn.jsp". Finally, the College received the International Standard Serial Number "**ISSN 2581-4931 (Print)**" **on June 01, 2018.**

We are proud that this journal is an add-on to the enriched catalogue of SRCC's publications and academic literature.

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