**American Journal of Modern Physics and Application**
2018; 5(2): 30-36
http://www.openscienceonline.com/journal/ajmpa

# A Battle for the Future: Quantum Computing Chips Markets Analysis in the Light of Game Theory

Doaa Salman Abdou[1, *], Amal Gamel Salem[2], Mohamed Samir[1]

[1]Department of Economics, October University for Modern Sciences and Arts (MSA), Giza, Egypt

[2]Faculty of Management, Ain Shams Academy, October, Egypt

## Email address

dsalman@msa.eun.eg (D. S. Abdou)

[*]Corresponding author

## To cite this article

Doaa Salman Abdou, Amal Gamel Salem, Mohamed Samir. A Battle for the Future: Quantum Computing Chips Markets Analysis in the Light of Game Theory. *American Journal of Modern Physics and Application.* Vol. 5, No. 2, 2018, pp. 30-36.

**Received**: May 25, 2018; **Accepted**: June 18, 2018; **Published**: July 24, 2018

## Abstract

Modern physics and microeconomic theories target to investigate market behaviors, but the deviations are what motivate us for more accurate understanding for these theories and its limitations. In the light of that this paper foresight the impact of quantum computing in the industry of computing chips and the practices applied since 1985. The paper review the history of this industry and linking the practices applied to game theory. The review of the artificial intelligent and quantum computing reflects on the industries productivity and competiveness, thus the paper target to insight the decision maker with required policies to lessen the battle in the future in this industry. The paper provides evidence on how industries in the future will monopolies to control the future.

## Keywords

Game Theory, Quantum Computing, Strategies, Price Discrimination

## 1. Introduction

Since the 1980s, physicists in academic labs and at firms such as IBM, Hewlett-Packard, and NEC have pursued a variety of quantum computing approaches, but none seems likely to deliver a working machine. In 1982, the Nobel prize-winning physicist Richard Feynman thought up the idea of a 'quantum computer', a computer that uses the effects of quantum mechanics to its advantage [1]. Scientists have made big strides towards building a quantum computer over the past five years, and now, quantum computing is becoming a reality and all the ingredients seem to be gathered for a quantum-driven 4th industrial revolution. Quantum computer device is computational power, from binary digital electronic computers. It holds the promise of solving complex problems that are practically insurmountable today, including intricate simulations such as large-scale financial analysis and more effective drug development. Quantum computing is an area of research that Intel has been exploring because it has the potential to augment the capabilities of tomorrow's high-performance computers.

It work significantly faster than any existing computer: where conventional computers would process a selection of numbers in a sequence, a quantum computer, being able to be in multiple states at one time, is able to process calculations simultaneously. This significantly reflects on productivity, the more productive and efficient the production of a company, the less average cost it incurs and the higher the profit. Technologically advanced products and highly sensitive ones require very complex and cutting-edge production techniques and machinery that are very difficult to improve further on.

Advancements in robotics and new age computing have been taken by storm with concepts such as artificial intelligent (AI) and quantum computing. AI bases its operation on accessing huge amounts of information, processing it, analyzing it and, according to its operation algorithms, executing tasks to solve certain problems. Due to the new computing architectures of the cloud, this technology becomes more affordable for any organization [2]. Quantum

computing is computing using quantum-mechanical phenomena, such as superposition and entanglement. A quantum computer is a device that performs quantum computing. They are different from binary digital electronic computers based on transistors. Whereas common digital computing requires that the data be encoded into binary digits (bits), each of which is always in one of two definite states (0 or 1), quantum computation uses quantum bits, which can be in superposition of states. As of 2018, the development of actual quantum computers is still in its infancy, but experiments have been carried out in which quantum computational operations were executed on a very small number of quantum bits. Both practical and theoretical research continues, and many national governments and military agencies are funding quantum-computing research in additional effort to develop quantum computers for civilian, business, trade, environmental and national security purposes, such as cryptanalysis. A small 20-qubit quantum computer exists and is available for experiments via the IBM quantum experience project. D-Wave Systems has been developing their own version of a quantum computer, which uses annealing. Large-scale quantum computers would theoretically be able to solve certain problems much more quickly than any classical computers that use even the best currently known algorithms. Quantum computers may be able to efficiently solve problems, which are not practically feasible on classical computers.

Quantum computing requires certain chips that operate on the principle of qubits, or quantum bits, making use of quantum mechanical phenomena to speed up computer processes and operations. Such quantum computing chips would allow for the creation of AI. The creation of AI, or artificial intelligence, would take the whole world to a new industrial revolution, many might argue, our last industrial revolution. Saying it would lead to a great leap forward is an understatement; it would lead to the equivalent of being able to fly not take leaps. AI would allow industries such as military, space, and all technologically based industries out there to reach places they have and would have never been able to reach. Therefore, it is important to many players that AI is reached and everyone wants to monopolize it, thus get their hands on it first.

## 2. Theoretical Literature

### 2.1. Price Discrimination Policies

As pricing policies difference from on company to another and from one product or service to another, there are different types of price discriminations that could be used in order to maximize profit using each one of them. Researcher stated that there are four main types of price discrimination in any market and they are: Firstly, pricing policy is the policy a manufacturer, or supplier of a good or service, sets to price his output for consumers to purchase [3]. Policies can and should be tailored to various competitive situations; a policy approach, which is becoming normal for sales, but is comparatively rare in pricing. Most manufacturing enterprises have a clear-cut advertising policy, product customer policy and distribution-channel policy, but pricing decision remains a patchwork of improvised decisions. In many well-managed firms pricing policy is being dealt with on a crisis basis which results in problems later on for those firms."

There are different types of pricing policies. The most profitable pricing policy is complete price discrimination, where each unit is priced at the benefit that the unit provides to its buyer. To implement this policy, however, the seller must know each potential buyer's individual demand curve and be able to set different prices for every unit of the product. The next most profitable pricing policy is direct segment discrimination. For this policy, the seller must be able to directly identify the various segments. The third most profitable policy is indirect segment discrimination. This involves structuring a set of choices around some variable to which the various segments are differentially sensitive. Uniform pricing is the least profitable way to set a price."

Price discrimination is a type of pricing policy, where a seller sets different incremental margins on various units of the same or similar product or service they provide. Complete price discrimination is the pricing policy, where a seller prices each unit of output at the buyer's benefit and sells a quantity where the marginal benefit equals the marginal cost. In it, the entire buyer surplus is extracted. Every buyer is charged the maximum she is willing for pay for each unit. An economically efficient quantity where all the opportunity for additional profit through changes in sales is exploited is reached. The supplier extracts a higher price for units that would be sold using uniform pricing and thus extends sales by selling additional units that would not have been sold otherwise. However, in order to reap the benefits of complete price discrimination the supplier requires information about each potential buyer's entire individual demand curveInvalid source specified.."

Other types of price discrimination practiced by firms are first, second, and third degree price discriminations. First-degree price discrimination involves charging consumers the maximum price that they are willing to pay. There will be no consumer surplus. Second-degree price discrimination involves charging different prices depending upon the quantity consumed; for instance, after 10 minutes, phone calls become cheaper or when electricity is more expensive for the first number of units. Third-degree price discrimination involves charging different prices to different groups of people. For example, student discounts, senior citizen rail card, peak travel, and cheaper prices by the time of the day (e.g. happy hour's in pubs – usually earlier on in evening where demand is lower). Product versioning is another way firms practice price discrimination, done by offering slightly different products as a way to discriminate between consumers ability to pay. For example, priority boarding tickets where in the same flight but for a premium, you get a shorter queue, or organic coffee and fair trade coffee, or first class and second class football tickets."

### 2.2. Market Types

Market types that price discrimination is applicable to are monopoly, oligopoly, monopolistic, and oligopolistic markets where producers have significant market power due to their small number, the tough barriers to entering the market, and demand on their output; also helps when their products have no substitutes and an inelastic demand. Price discrimination is most effective in the market for an essential good that is highly monopolistic, as the supplier's market power would far exceed that of the consumers' and the same scenario is where the consumer gets hurt most.

On the other hand, price discrimination can occur from the demand's side in a monopsony. While this article has discussed price discrimination in terms of sellers discriminating against buyers, it can also happen the other way around. In other words, firms with high buying, or monopsony, power can discriminate in favor of a preferred seller. A profit-maximizing monopsonist restricts purchases and lowers prices."

As the antitrust law is meant to curb monopolies from formulating, the Robinson-Patman Act is a federal law that prohibits anticompetitive practices by producers, specifically price discriminationInvalid source specified.."

## 3. Game Theory

Game theory is the formal study of decision-making where several players must make choices that potentially affect the interests of the other players. It is the formal study of conflict and cooperation. Game theoretic concepts apply whenever the actions of several agents are interdependent. These agents may be individuals, groups, firms, or any combination of these. The concepts of game theory provide a language to formulate structure, analyze, and understand strategic scenarios.

### 3.1. History and Background

The earliest example of a formal game-theoretic analysis is the study of a duopoly by Antoine Cournot in 1838. The mathematician Emile Borel suggested a formal theory of games in 1921, which was furthered by the mathematician John von Neumann in 1928 in a "theory of parlor games." Game theory was established as a field in its own right after the 1944 publication of the monumental volume Theory of Games and Economic Behavior by von Neumann and the economist Oskar Morgenstern. This book provided much of the basic terminology and problem setup that is still in use today. In 1950, John Nash demonstrated that finite games have always have an equilibrium point, at which all players choose actions, which are best for them given their opponents' choices. This central concept of non-cooperative game theory has been a focal point of analysis since then. In the 1950s and 1960s, game theory was broadened theoretically and applied to problems of war and politics. Since the 1970s, it has driven a revolution in economic theory. Additionally, it has found applications in sociology and psychology, and established links with evolution and biology. Game theory received special attention in 1994 with the awarding of the Nobel Prize in economics to Nash, John Harsanyi, and Reinhard Selten.

At the end of the 1990s, a high-profile application of game theory has been the design of auctions. Prominent game theorists have been involved in the design of auctions for allocating rights to the use of bands of the electromagnetic spectrum to the mobile telecommunications industry. Most of these auctions were designed with the goal of allocating these resources more efficiently than traditional governmental practices, and additionally raised billions of dollars in the United States and Europe.

### 3.2. What Is a Game

It is a formal model of an interactive situation. It typically involves several players; a game with only one player is usually called a decision problem. The formal definition lays out the players, their preferences, their information, and the strategic actions available to them, and how these influence the outcome.

Since all players are assumed to be rational, they make choices which result in the outcome they prefer most, given what their opponents do. In the extreme case, a player may have two strategies A and B so that, given any combination of strategies of the other players, the outcome resulting from A is better than the outcome resulting from B. Then strategy A is said to dominate strategy B. A rational player will never choose to play a dominated strategy. In some games, examination of which strategies are dominated results in the conclusion that rational players could only ever choose one of their strategies.

### 3.3. Prisoner's Dilemma

The Prisoner's Dilemma is a game in strategic form between two players. Each player has two strategies, called "cooperate" and "defect," which are labeled C and D for player I and c and d for player II, respectively. Figure 1 shows the resulting payoffs in this game. Player I choose a row, either C or D, and simultaneously player II chooses one of the columns c or d. The strategy combination (C; c) has payoff 2 for each player, and the combination (D; d) gives each player payoff 1. The combination (C; d) results in payoff 0 for player I and 3 for player II, and when (D; c) is played, player I gets 3 and player II gets 0.

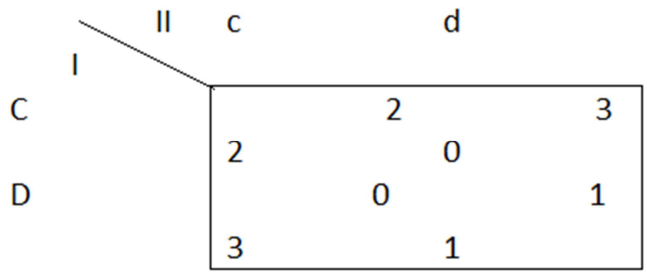


***Figure 1.*** *The Prisoner's dilemma game.*

In the Prisoner's Dilemma game, "defect" is a strategy that dominates "cooperate." Strategy D of player I dominate C since if player II chooses c, then player I's payoff is 3 when choosing D and 2 when choosing C; if player II chooses d, then player I receives 1 for D as opposed to 0 for C. Hence, D is indeed always better and dominates C. In the same way, strategy d dominates c for player II.

There is obvious "inefficiency" in the outcome of the Prisoner's Dilemma game. For example, the game is fundamentally changed by playing it more than once. In such a repeated game, patterns of cooperation can be established as rational behavior when players' fear of punishment in the future outweighs their gain from defecting today.

### 3.4. Important Game Theory Concepts

Important concepts in Game Theory are Nash equilibrium and Zero-sum games. Nash equilibrium, also called strategic equilibrium, a strategy, for each player, wherein neither player can unilaterally change his strategy and get a better payoff. The central concept of Nash equilibrium is much more general. Nash equilibrium recommends a strategy to each player that the player cannot improve upon unilaterally, that is, given that the other players follow the recommendation. Since the other players are also rational, it is reasonable for each player to expect his opponents to follow the recommendation as well. Furthermore, a game is said to be zero-sum if for any outcome, the sum of the payoffs to all players is zero. In a two-player zero-sum game, one player's gain is the other player's loss, so their interests are diametrically opposed. An interesting concept in Game Theory is Common Knowledge. A fact is common knowledge if all players know it, and know that they all know it, and so on. The structure of the game is often assumed to be common knowledge among the players.

### 3.5. Types of Strategies

Pure strategies are ones where a player of a game or a firm who takes a specific action to maximize his payoff or makes specific strategy to increase their payoff. A mixed strategy is one in which a player makes random choice between two or more possible actions that can be taken but those actions taken are based on a set of chosen probabilities. The basic difference between pure strategy and mixed strategy is that in pure strategy people makes specific actions but in mixed strategy actions are taken randomly or actions are based on probabilities. The Nash equilibrium and Dominant strategy are examples of strategies that players may adopt as well. Many other strategies exist.

The way in which Game Theory fits in with price discrimination is that since price discrimination done by a firm affects other firms in the market, then pay-offs of firms (players) in the market are affected. Therefore, firms must choose their strategies carefully with respect to the strategies of other players in the market.

## 4. Gains and Losses from Price Discrimination for Producers and Consumers

### 4.1. Advantages of Price Discrimination for the Producers

From the producers' point of view there are many different advantages for them when they price discriminate and these are: first, profit maximization which was previously mentioned above and this done because the firm tries to collect the total consumer surplus to it. Another way that increases profits is the act of segmentation or differentiating between the elastic groups of people who pay less money than the inelastic group which pays at a higher price. Second, Economies of scale is another advantage to the producers because when they start segmenting more people and selling their products to more people this means that their overall production and efficiency will increase as well because there will be new segments of consumers motivated to buy the product at lower prices so they will become a part of the new segment, or the elastic sub market. Third, getting rid of excess supply of goods is another advantage because this means that there will never be a surplus in the products as they will either be sold at a low price or a high price, this leads to better use of space as the firms will be able to get rid of existing stock easier than before price discriminating. Fourth, help small firms survive because when small firms encourage consumers to buy their products this will help the firms keep making profit and stabilize their stage of growth as much as possible rather than small firms closing as a result of not being able to compete with every other large firm. Fifth, understanding the market is another thing that entrepreneurs gain from price discrimination because now they know who are the segments that will pay high and be price inelastic and the other segment that will pay lower and be price elastic.

This kind of knowledge may give the firms the chance to export their product as a result of segmentation and target bigger markets. Sixth, more efficient employees and better shopping experience for the consumers is another advantage because if the offers given by price discrimination encourage the consumers to come at different times of the day, early in the morning for example, then this will lead to a decrease in the number of queues and waiting lines there is at the crowded times of the day and this will also lead to more efficient staff as they will be better employed throughout the work day. Finally, decreasing the costs and increasing revenues is also another advantage that producers gain from because when the consumers increase in number while the production stays the same then this means there will be more profits made available, and if not that then the marginal costs of production will decrease [4]

### 4.2. Advantages of Price Discrimination for the Consumers

Like producers, the consumers will also have advantages from price discrimination and these are mainly: 1) the lower prices they get obviously are an advantage especially to the elastic group that is very much responsive to the increase or decrease in prices. 2) Another advantage that the consumers see is that they more encouraged to try new things with their families as they will get an offer for their children for example so if they weren't going to go the cinema because they think they will pay a lot of money to do so, now they will be happy to go all together because they will not pay the same amount of money. Another advantage is that they will gain from benefiting for the sales of group because sometimes price discrimination comes in the form of getting the discount according to the quantity or the number of units bought so also the consumers will be more encouraged to buy ten units and get the discount rather than five units without the discount for example. Lastly, 3) gaining for the decreased costs of the firm because when the advantages from the producers point of view are met, then this means that consumers will also benefit from this decreased costs for example but in the quality of the product itself because if the firm is able to produce more units will less costs and more efficiency then this will also be reflected on the quality of the product that the consumer will receive or the high service quality that will be received [4]

### 4.3. Disadvantages of Price Discrimination in the Market

The disadvantages of price discrimination are for consumers, producers, and the market. The main disadvantage that affects the consumers is that sometimes the inelastic sub market will pay so much more than the elastic market to the extent that these consumers could transform the consumer surplus to producer surplus, or in other words, profits to the firm. As a result, the welfare of this group of people is somehow decreased as they pay a large portion of their incomes in a product that could've been bought a much lower price. The main disadvantage of price discrimination according to the firm is that the monopolistic power of the firm might get affected according to the consumers demand. This puts the firm's power to change the price in danger because without this kind of power, the firm will not be a monopoly anymore and this means that it won't be able to price discriminate [5]

## 5. Quantum Potential Market

Persistence Market Research's new study on global market for quantum computing emphasizes the monumental impact of rising need for high-level computing on the market's growth Which will have potential applications in a wide variety of sectors such as aerospace and defense, cyber security, finance or healthcare, is expected to grow. This growth is mainly driven by the investments of the stakeholders of the quantum computing market and also stimulated by the growing use of quantum cryptography for security applications. On the grounds of such drivers, more than US$ 23 Bn revenues are anticipated to be reaped through adoption of quantum computing across the globe by the end of 2025. During this decadal forecast period, the global market for quantum computing is expected to expand exponentially at a stellar CAGR of 30.9%. Also, is expected to bring the following benefits: accelerate research into diseases such as cancer, find new drugs and pioneer new treatment regimens. [6]

In addition to the global market for financial assets, some problems in Finance are very difficult to solve with current technology and can take years of computing time. These include: Dynamic portfolio optimization, risk management and regression analysis, option pricing for complex derivatives (which are path dependent). Computing different paths is time consuming and expensive. [7] Financial services are one of the markets most dependent on IT because of a reliance on security and the need to deliver differentiated services. There is a new ways of communicating and interacting with financial services digitally (e.g. online and mobile banking, peer-to-peer payment platforms and digital currencies), as well as the continuing improvements in computing power, have led to increased concerns over cyber security. It is an ongoing challenge for encryption methods to keep pace with the sophistication and processing power of technology that is capable of compromising the protection they offer.

In addition to Machines are possible to have some artificial intelligence like human beings owing to particular algorithms or software. Such machines could learn knowledge from what people taught them and do works according to the knowledge. In practical learning cases, the data is often extremely complicated and large, thus classical learning machines often need huge computational resources. Quantum machine learning algorithm, on the other hand, could be exponentially faster than classical machines using quantum parallelism. Here, we demonstrate a quantum machine learning algorithm on a four-qubit NMR test bench to solve an optical character recognition problem, also known as the handwriting recognition. The quantum machine learns standard character fonts and then recognizes handwritten characters from a set with two candidates. To our best knowledge, this is the first artificial intelligence realized on a quantum processor. Due to the wide spreading importance of artificial intelligence and its tremendous consuming of computational resources, quantum speedup would be extremely attractive against the challenges from the Big Data [8].

Countries such as United States, China and now Australia are investing in cutting-edge computing, with important security and defense implications. The Australian Government recently announced plans to invest $26 million in the development of quantum computing technology as part of the National Innovation and Science Agenda (NISA)." It emphasizes quantum computing as an important area for government investment based on its ability to produce "jobs

and economic growth." And while this industry could certainly be "worth billions," it offers much more than financial prosperity: quantum technologies could play a significant role in our future defense and security [9]. Finally, creating highly complex software systems such as aircraft, reusable space rockets, or an aircraft carrier requires an enormous amount of effort to verify and validate that every system operates correctly.

## 6. Quantum Computing Chips Market

Back in 2015, IBM introduced a superconducting chip it had developed; it was a worthy contender of being the first quantum-computing chip out there [10]. If successfully developed, quantum computers could effectively take shortcuts through many calculations that are difficult for today's computers. What that means is a completely new level of efficiency that would boost all kinds of industries onto an utterly new level of operational and manufacturing efficiency. This could be greatly beneficial to humanity in the fields of financial inscription and security, health and pharmaceutical research, and helping scientists simulate experiments beyond their current imaginations. It could also be gravely damaging, nonetheless, when used in terms of military equipment and weaponry, surveillance and crossing boundaries of privacy, and if used as a means to higher efficiency by replacing human labor. Google, NASA, Microsoft, IBM, and the U.S. government are all working on the technology, making them the only players in the market, and making the market an oligopoly. Nonetheless, Google and IBM are ahead of the race to manufacturing the first altogether functional superconducting chip with qubits as there are different ways to make qubits, and superconducting circuits, like those used by IBM and Google, are one of the most promising [10].

In 2018, Google announced Bristlecone, its all-new quantum-computing chip. Google says that the Bristlecone chip could maintain sufficiently low error rates to reach a significant threshold known as quantum supremacy. That is the point at which a quantum computer can perform a well-defined calculation faster than a digital supercomputer. The new chips are being operated in Google's Quantum AI lab right now [11]. Google is certainly the dominant player in this game, which is the market for sci-fi like technological advancements.

In the 2020s, we will have quantum computers that are significantly better than super computers today, but they most likely won't be in mass use by governments and companies until the 2030s. Eventually toward the end of the 2030s and early 2040s they'll shrink down to a size and cost viable for consumer use. Before that point even with the exponential growth of technology I don't think that it would be cost efficient enough for the average consumer to replace regular computing with quantum computing.

Quantum computers are indeed currently out of the price range of the average consumer and will likely stay that way for a few years at least. The $15 million price tag for the D-Wave 2000Q has a long way to drop before it makes it to a Black Friday sale. But the technology is rapidly advancing, and experts are optimistic that we will soon see a functioning quantum computer in all of its glory. In fact, an international team of researchers wrote in a Review, "Recent improvements in the control of quantum systems make it seem feasible to finally build a quantum computer within a decade [11].

## 7. Conclusion

Seeing that Google is the far superior player in this race towards the future, due to numerous factors, it is able to follow a dominant strategy. Google follows a dominant strategy in terms of selling its prototypes, setting their prices at the highest possible, with no competition from the rest of the institutions competing in the market. Google is so dominant that other players such as the United States government's military and NASA employ Google's help, in terms of research capabilities and more, to advance further in the field of quantum-computing. Google is also capable of following a dominant strategy in attracting top-notch researchers and investments to further their attainments in reaching their goal of a qubit utilizing superconducting chip allowing for AI to come to life. The economic impact of quantum computing can be considered from both research and business perspectives. Research in quantum computing by universities and companies is generating revenue for suppliers on a local, national and global basis, through the buying of specialist equipment and components. Research groups are in the race to realize the world's first universal quantum computing machine where they can harvest the gains from their research.

## References

[1] Simon. Bone & Matias Castro, a brief history of quantum computing, https://www.doc.ic.ac.uk/nd/surprise_97/journa/vo14/spb3/

[2] Shabbir, J., & Anwer, T. (2018). Artificial Intelligence and its Role in Near Future. *arXiv preprint arXiv:1804.01396*.

[3] Hazledine, T. (2006). Price discrimination in Cournot–Nash oligopoly. *Economics Letters*, *93* (3), 413-420.

[4] Welsch, M. (2017). Europe's Energy Transition: Insights for Policy Making. Academic Press.

[5] Team, A., & Gottschling, J. (2015). Business models for flexible production and storage. Policy, 4.

[6] Global Quantum Computing Market is Expected to Reach US$ 23 Bn by 2025 - PMR's Study, NEWS PROVIDED BY Persistence Market Research Pvt. Ltd. NEW YORK, July 26, 2017 /PRNewswire/ --

[7] Paul Laverne, how quantum computing will affect global finance, Market Mogul, March, 19, 2018.

[8] Li Zhaokai, Liu Xiaomei, and Xu Nanyang, *Experimental Realization of Quantum Artificial Intelligence*, Cornell University Library, preprint arXiv:1410.1054, 2014.

[9] Quantum Computing. Available from: http://www.lockheedmartin.co.uk/ca/what-we-do/emerging-technologies/quantum-computing.html.

[10] Simonite, T. (2015, April 29). IBM Shows Off a Quantum Computing Chip. Retrieved from MIT Technology Review: https://www.technologyreview.com/s/537041/ibm-shows-off-a-quantum-computing-chip/

[11] Whitwam, R. (2018, March 6). Google Announces 'Bristlecone' Quantum Computing Chip. Retrieved from Extreme Tech: https://www.extremetech.com/extreme/265105-google-announces-bristlecone-quantum-computing-chip

[12] Christiana Reedy, when will quantum computers be consumer products? July 31, 2017, available from https://futurism.com/when-will-quantum-computers-be-consumer-products/