PERINTIS eJournal

PERINTIS eJournal, **2017**, Vol. 7, No. 2, pp. 111-128

EMERGING TECHNOLOGIES WITH DISRUPTIVE EFFECTS: A REVIEW

Airini Ab Rahman[1], Umar Zakir Abdul Hamid[2]*, Thoo Ai Chin[1]*

[1]Faculty of Management, Universiti Teknologi Malaysia, Johor Bahru, Malaysia

[2]Moovita Pte Ltd, 8 Burn Road Trivex Building, 13-01, 369977 Singapore

*Corresponding author: acthoo@utm.my; umar@moovita.com

ABSTRACT

Since the last decade, several technologies have been abruptly influencing our lives. Among the notable major changes in the human society is the way humans interact with each other, which now involves the social media heavily where this is previously unknown to the masses. This type of technology is called Disruptive Innovation, a type of technology which has the potential to alter how human lives, market trends as well as other aspects including transportation and communications. Studies show that in the next few years, there are plenty of technology with the disruptive features. The new technologies, part of the domino effect of previous emerging technologies, include autonomous vehicle, the blockchain as well as Internet-of-Things. Despite the rapid advent, little discussion has been done to discuss and summarizes the emerging technologies in a single work in Malaysia. This brief survey is written as an effort to initiate the discussion, particularly in Malaysia about the disruptive innovation. It gives an introductory idea to the general audience, as well as academician and practitioners about the examples of the innovation, as well as brief discussion about the future studies which need to be commended in relation to the current development. This work is hoped to speed up the implementation of the emerging technologies in Malaysia as well helping and guiding policymakers, practitioners as well as academicians in understanding the phenomenon.

Keywords*: Disruptive innovation, Emerging technologies, Fourth industrial revolution.*

1.0 INTRODUCTION

Human's tendency to innovate is fueled and encouraged by their creative ability. According to Amabile et al., it is impossible to witness an innovation without the involvement of the human creativity [1]. The ability to identify the new problems and solutions, analyzing the information, yielding latest theories and validating the ideas is part of the human creativity, which plays a deep role in the innovation throughout the history [2]. According to Christensen [3], innovation is classified into two main categories, sustaining and disruptive. Figure 1 illustrates their respective brief definitions.

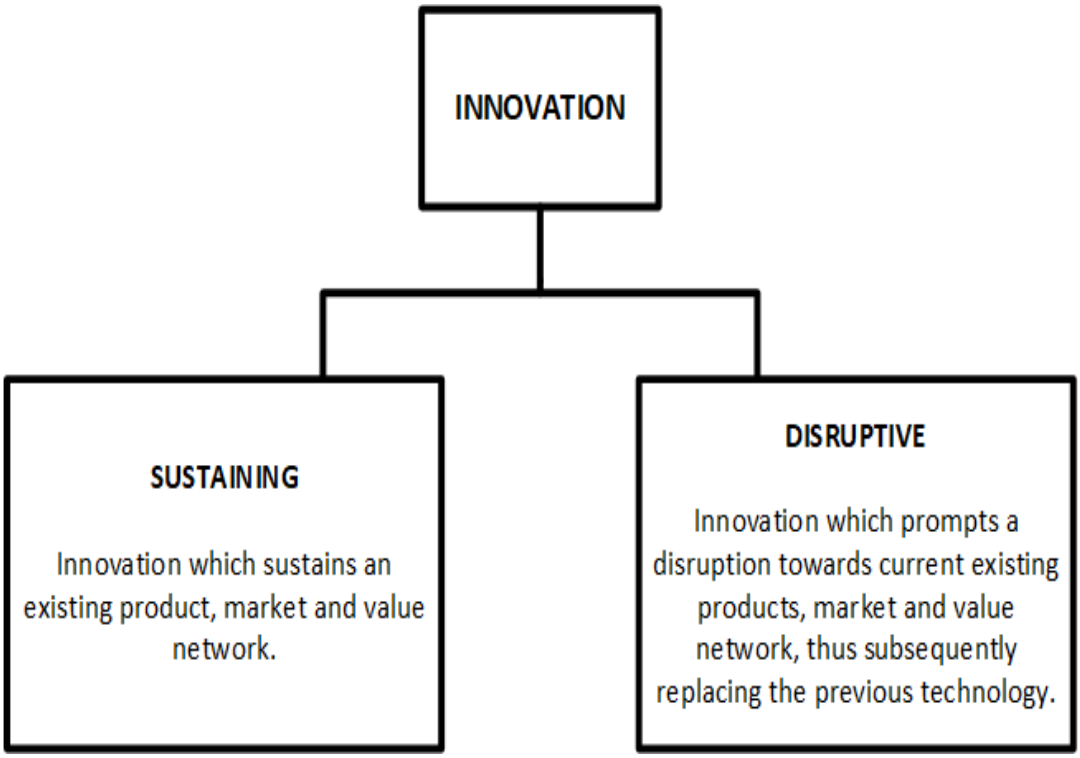

Figure 1. Two types of innovation [3].

Sustaining innovation refers to the type of innovation, which does not relatively impact the current available market and society. It may come in as an improvement type to the current product. However, it does not necessarily create a new product [4, 5]. Disruptive innovation on the other hands is the innovation, which stimulates the creation of new market and business niche [6, 7]. It yields a new concept of product values which overrides the current market. According to Zeleny [8], the entity which is most affected by the disruptive innovation is the support network of current existing high technology (Technology Support Net). However, due to the human creativity and dynamic nature of human creativity and innovation, technology always evolves [9]. This dynamic nature prompted the birth of several industrial revolutions along the history. According to Teich et al [10], the term 'industrial revolution' has been coined as early as in 1799 by Louis-Guillaurne Otto, which mentioned that France had joined the race to industrialize. After several decades and types of industrial revolutions, it is now entering the fourth phase, which is called Fourth Industrial Revolution (FIR) [11]. FIR stimulates the development of several types of new technology, which include the focus on artificial intelligence and automation of the system. With the advent of many new technologies, the discussion on the disruptive innovation has been getting more focused now. Due to the new technologies create a new market and will change the society, a study on it should be done for

policymakers and researchers to understand the issue. Example of the disruptive innovation can be seen on Facebook. Prior to its existence, the idea of connecting with each other and hanging out on the internet alone is quite strange. Though the internet has existed prior to that, only with such disruptive innovation that the people in the rural areas are also affected [12].

Thus, for the FIR, the emerging technologies are expected to bring the same effects as Facebook to the society and the world. In Malaysia, the talks of Fourth Industrial Revolution have gained some attention recently with the report of the government to focus on tax incentives for the FIR [13]. However, despite the progress, not much has been conveyed to the ground level and among the practitioners in Malaysia. Thus, the authors aim to write and share about the current emerging technologies and their disruptive potential towards changing the humankind.

This work is organized as follows. The next section briefly describes the background of disruptive innovation, which includes its definition and previous examples of technology with disruptive abilities. In section 3.0, the authors review ten emerging technologies with the disruptive abilities. The discussions encompass of their backgrounds, current implementations, their potential disruptive ability as well as future considerations regarding the development. In the final section, the conclusions of the work are denoted, where considerations of future works are also included. This survey will be beneficial for identifying future potential researches for policymakers as well as practitioners in Malaysia as well as other countries.

2.0 DISRUPTIVE TECHNOLOGY

This section discusses the background of the disruptive innovation as well as examples of previous disruptive innovation with disruptive ability.

2.1 History

In a study by Christensen, a Harvard professor who came up with the idea of disruptive technology, and later renamed it to disruptive innovation – it is noted that the main factor which caused disruptive innovation to be disruptive is due to its impact on the business model and current system (and society) [3, 14]. Christensen later denotes the theory regarding disruptive innovation's emergence, which possesses similar pattern in many scenarios [3, 14]. To allow the better understanding of the disruptive innovation idea, the authors illustrates the idea in Figure 2.

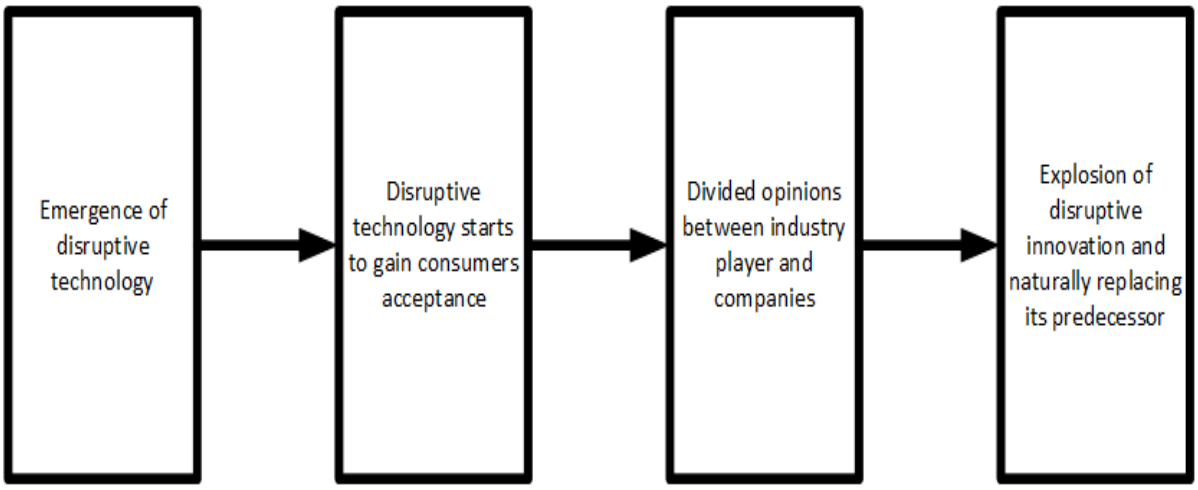

Figure 2. Disruptive innovation concept [3, 14].

As can be seen in the Figure 2, the emergence of certain disruptive technology begins with its rise, whereas can be expected, due to its non-conformist feature, could not initially attract the consumer perception due to low acceptance yet [15]. In the second phase, the distinctive features of the product subsequently gradually attracted a significant number of the new consumers. Following the second phase, Christensen noted two different scenarios and actions done by two sides. The first one is the big industry player, who feel resilient to change and improve their product according to the trend, thinking the consumers are not attracted to the new 'emerged' feature. On the other side, there is a new market player who manipulates the widespread publicity of disruptive technology and assimilated it into their products. Christensen finally mentioned that usually, the disruptive innovation explodes and the new technology naturally replaces its predecessor and the predecessor lost their influences. Many examples can be shown in relation to this short anecdote. For example, the collapse of the major players due to their reluctance to adapt to the new changes as well as the stories of how start-up companies come to change the world [16, 17].

2.2 Examples of Previous Disruptive Technology

Before proceeding with the review of current emerging technology which is expected to disrupt the current industry, the authors review some of the previous disruptive technology in the last few decades (Table 1).

Table 1. Previous examples of technology with disruptive impact.

Technology	Disruptive Impact	References
Digital Media Store	Before 2003, most of the consumers buy their favorite music in the form of the Compact Disc (CD). With the emergence of Digital Media Store such as iTunes, led to the decline in the sales of physical press album such as CD and Long Play Vinyl (LP). In addition, continuous declination led to the demise of cassette tapes.	[18-20]
Streaming Video Portal	With the emergence of streaming video portal such as Netflix, people started to watch video online. This subsequently led to the declination in TV Cable and DVD sales. The Netflix series such as, Stranger Things which saw very high view rating, support this.	[21, 22]
Smartphones	Smartphones start to be used extensively since 2013. Since then, many products were created solely due to the existence of smartphones such as Instagram, Snapchat, WhatsApp and so on. These products did not exist several years backward.	[23, 24]
Internet	The existence of Internet prompted the birth of a lot of other technologies such as e-mail, social media, smartphones as well as file sharing among many others.	[25, 26]

These examples above show the existing disruptive innovation and their disruptive effects toward the existing technology. For the fourth industrial revolution however, there are several new emerging technologies which are expected to possess the disruptive feature. This will be discussed in the next section.

3.0 CURRENT AND FUTURE DISRUPTIVE TECHNOLOGY

Fourth Industrial Revolution, which revolves around the development of many new emerging technologies with disruptive innovation feature, is said to disrupt a lot of industry sectors globally [11]. In this section, ten examples of the emerging technologies with the disruptive feature are listed. In addition to that, for each technology, discussions will revolve on their background and benefits, their disruptive potential as well as the future works which are required to be studied for their implementation. Figure 3 below illustrates the emerging technologies with the disruptive ability which will be discussed in the next subsections.

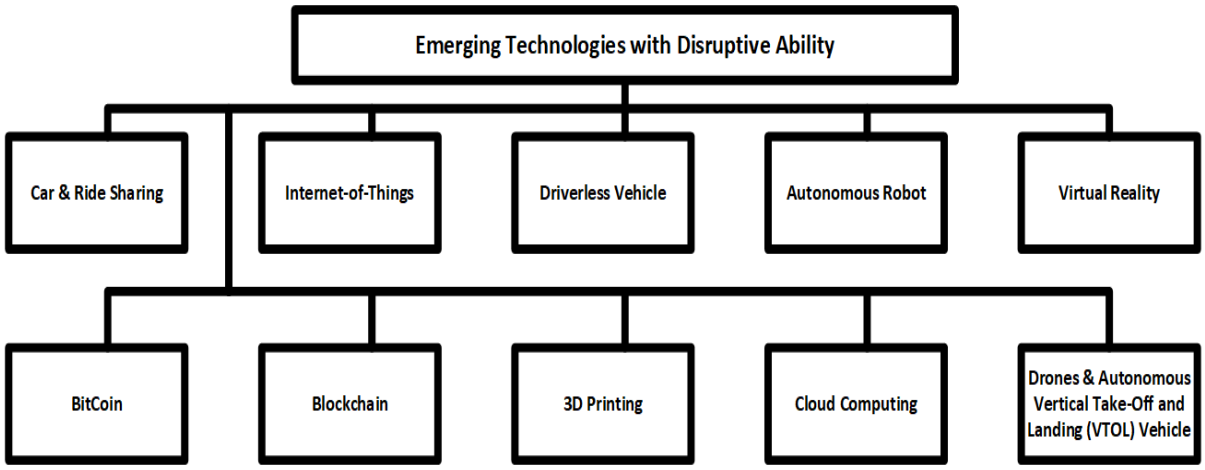

Figure 3. Emerging technologies with disruptive ability.

3.1 Car and Ride Sharing

Car sharing can be defined as a car rental service which allows the consumer to rent cars for short time and errands [27]. Ridesharing, on the other hand, works like traditional taxi service, where it allows the consumer to share the rides to a certain destination. However, the differences are the ridesharing utilizes the idea of carpooling, where the owner of the car utilizes their empty seats to transport their potential customer [28]. Most of the car and ride-sharing service utilizes the common technology possessed by the majority of the modern city inhabitants, such as Global Positioning System (GPS) and smartphones as well as social networks [29]. Figure 4 depicts the usage of car and ride sharing.

Figure 4: Car and ride sharing heavily relies on the usage of smartphones among the consumers.

According to Katzev [30] based on his study of the car sharing in Portland, most of the users use car sharing due to three factors, which include the need to use a vehicle and the financial savings which will be inherited by joining the service. The second one is due to the fact that the membership is more important to the vehicle owners rather than the non-owners. In addition, most of the participant in the car-sharing program in Portland sold their vehicle after the program, and 53% of them canceled the car purchase intention. Car sharing has been extremely popular, particularly in major cities, since the service allows for a service which the public transport does not cover. The extreme popularity of Uber, a ride-sharing company, has led to the formulation of the word *uberisation*, which refers to the peer-to-peer ridesharing pioneered by the company [31]. In addition, it is noted in a study by d'Orey et al. [32] that the major factor of consumer acceptance in ride-sharing services is the economic factors. Among the notable examples of Car and Ride Sharing is Uber, Lyft and Grab [33, 34]. Car and ride sharing is a rapidly expanding economy segment, and with the advent of self-driving cars, new discussions revolve around the ownership of the autonomous vehicle. The idea is that the ownership of autonomous vehicles will not be possessed by private consumers, instead, it will be shared among city citizen [35]. This in return has a strong disruption effect on the current car ownership idea. Thus, a study should be done on several issues regarding this rapid progress field, such as security, policymaking and insurance.

3.2 Internet-of-Things

In 1999, Kevin Ashton coined the term "Internet of Things" (IoT) [36]. Its idea is to allow everyone to be connected to everything via the internet usage. Theoretically, this means soon, all the vehicles, vending machines, ticketing service and even the places of living will be connected to the Internet, which in return allow the automation of more industry. This in return will allow for more artificial intelligence-based device creation. Among the examples are [37]. Companies like Intel are racing towards the investment in IoT [38]. The disruptive potential by the IoT is that it will allow for each of our devices to be connected to the internet to the network [39]. Among the concerns involved in the IoT development are data security, network security as well as the rapid demands of the usage of internet. Thus, efforts should be put to consider all of these issues prior to the advancement of IoT in certain countries.

3.3 Driverless Vehicle

One of the major features of FIR is Autonomous Vehicle (AV). It allows the vehicle to navigate itself without the interference of human driver. Major companies are racing in developing autonomous vehicles, and it is expected to be navigating on the road by the general audience by the year 2025 [40]. Globally, major research universities are working towards the development of a fully autonomous vehicle such as University of Berkeley, California, TU Graz as well as Smart Mobility Research Center in Tokyo [41-43]. Despite having slower progress in the field, a handful of research has been done in Malaysia for AV development [44-46]. However, most of the cited studies focus on the engineering and technical aspects of the AV and not on the policymaking field. Thus, study should also be focused on the economics,

marketing as well as driver acceptance area. This is due to the ability to reduce fatalities by the driverless vehicle will benefits country like Malaysia, where the number of road accidents is still high. In addition, the combination of AV and car sharing will lead to the reduced car numbers and subsequently help in expediting the development of the smart city. Among notable examples can be read in the work of Zanella et al. [47]. In addition, the AV will not only focus on highway vehicle but also other usages such as snow cleaning technologies, as has been done by Daimler [48]. This show the vast disruptive potential of the new technology.

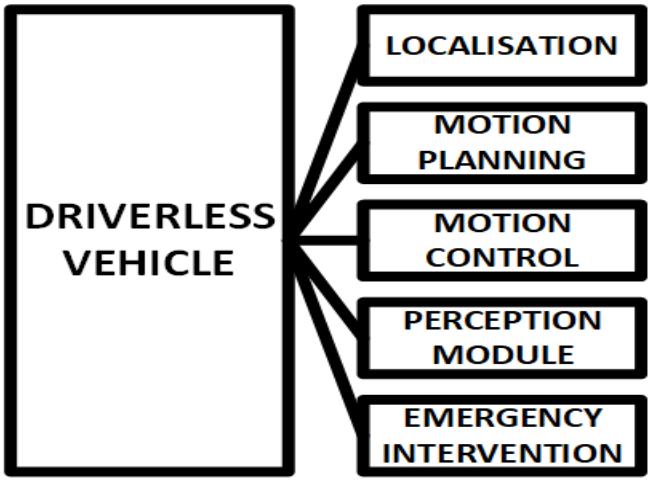

Figure 5: Ability of driverless vehicle to navigate itself encompasses of these modules, among many others [40, 45].

3.4 Autonomous Robots

Asimo is one of the first known projects of autonomous robot to the public [76]. Prior to that, the knowledge of autonomous robot has been shown in science fiction films. In addition, there are many new startups emerged in the said field due to the ability to create autonomous robot easily with the induction of technology like Arduino [49]. Autonomous robot and IoT will allow the creation of robots which can work in public services, thus subsequently expedite the process [50]. However, concerns involve whether the job opportunity will be reduced or not with the induction of robots into the industry. Study should be done according to this to study the consumers' acceptance [51].

3.5 Virtual Reality

The discussions on Virtual Reality (VR) has started since the 1960s. One of its initial development is done by Philco Corporation for military purpose to allow the military personnel to have a simulated experience in high risks training places such as underwater or up in the air [52]. Virtual reality has since been a stamp depiction of the future prediction, especially in the

post-apocalypse films [53, 54]. However, in recent years, it has faces resurgence with the advent of other computing devices technology. According to the Merriam-Webster Dictionary, Virtual Reality is defined as "*an artificial environment which is experienced through sensory stimuli (such as sights and sounds) provided by a computer and in which one's actions partially determine what happens in the environment*" [55]. In other words, VR allows us to be in a virtual world perceived by our eyes. Among current VR application is in the video games where companies such as Oculus Rift has created a platform to play the game with their VR headset [56]. The unique feature of VR possesses several benefits where in the future it will allow the children to go to the school without really attending the school [57]. In addition, the higher education can be provided to people from far away location with approximately similar experience of attending the college. Thus, this will enlarge the scope of education. Besides that, it will allow people with health issues to be working from home or school [58]. Thus, this in return has the disruptive feature to disrupt current technology support network of several fields in the education and medical industry, for example. However, as human nature needs to interact with each other, the psychology and social effect of VR should be studied to prevent the cases of critical social reclusion effect.

3.6 Bitcoin

In 2008, Satoshi Nakamoto published a paper entitled "Bitcoin A Peer-to-Peer Electronic Cash System" which initiated the Bitcoin phenomenon globally [59]. Later, it was revealed to the public where the name is a pseudonym to the creator of Bitcoin, which might consist of a single person or a group [60]. Bitcoin is a cryptocurrency, which allows for digital payment transactions with no central authority or issuer [61]. Its cryptocurrency nature means it is utilizing the cryptography, which in return allow for a secured transaction, without the existence of third parties. Since its induction, many studies have been done about it. In an article by Forbes [62], it is noted that Bitcoin's total market cap has reached $100 billion. The big potential of Bitcoin is showed by the Google Trends findings of the searches relating to its name. With the buzz revolving around 4IR, the Google Trends results on 11 November 2017 about the search regarding Bitcoin has shown that the searches are increased by more than 300% since 11 October 2015 (Figure 6). This shows the rising interest in Bitcoin [63]. Marc Andreessen in his article mentioned that Bitcoin has several benefits which include enabling micropayments and the potential of fighting the spam [64]. The disruptive innovation feature of Bitcoin led to the birth of another disruptive innovation called Blockchain, which is discussed in the next subsection. In addition, a peer-reviewed journal called Ledger is introduced in the year which mainly discussed the cryptocurrency and Bitcoin [65]. However, several concerns need to be discussed for Bitcoin including the privacy and security risks during the usage of the application.

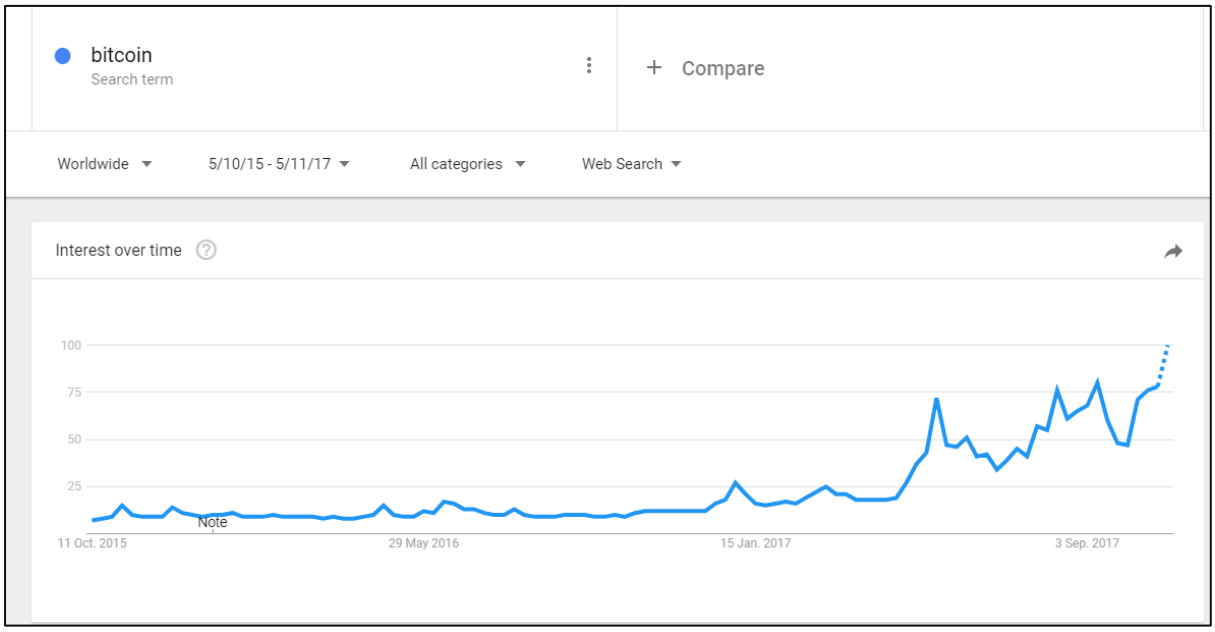

Figure 6: Snapshot of google trends searches for the term 'Bitcoin', where it shows rising interests since 2015 [63].

3.7 Blockchain

The disruptive feature of Bitcoin creates another disruptive technology, which is called Blockchain, a type of distributed ledger technology. Blockchain (initially written as Block Chain) is the one of the major features which brings Bitcoin to success. According to Lou Carlozo [66], blockchain is a virtual log of financial records which is completely public and frequently updated by public users. This publicly done transaction led it to be considered by experts to be hard to corrupt. Lou then reiterate the definition by defining Blockchain as a record of continuous logs of business done in blocks. One of the main benefits of Blockchain is that it allows a financial transaction to be done without having to have an intermediary third person party to be in between the transaction. This is different compared to the current online payment where it demands the intervention of the banking company or other payment methods. At the 2016 World Economic Forum, it is disclosed that more than 24 countries are currently involved in the study of blockchain and more than 25000 patents are filed since 2013 for the blockchain [67]. With over 1.4 billion values of investments in the past 3 years for the technology, it is evident of the disruptive effect of blockchain [67]. However, recently, the discussion has been done for Blockchain to be used in other fields. With the advent of Artificial Intelligence and IoT, it is believed that the potential of blockchain will outreach other fields besides its current major usage for Bitcoins. More of the discussions can be found elsewhere [67]. The challenge however is to ensure that for future work, to ensure all the distributed ledger are done correctly, a lot of collaboration between the financial service provider, government as well as the developer are required for safety purposes.

3.8 3D Printing

3D Printing is a concept where it allows the 3D printer to print everyday things. It is a process of utilizing the three-dimensional computer-aided design data sets for producing 3D real physical model [68]. According to Stephen Nigro of HP [69], the 3D market will be valued at 18$ billion by 2021, which saw the rise of 30% from the current value. He further enlisted that major giants in the manufacturing field like GE, SAP and HP are actively investing in the 3d Printing. This is to allow the technology to be mass produced for general usages. Among future potential of 3d printing usage is in the medical field [70]. Among the future potential of 3D printing is the ability to create DIY small houses in urban areas. This might reduce the homeless issues in certain cities. 3D Printing also has the potential to create a low-budget manufacturing industry.

3.9 Cloud Computing

Cloud computing is the act of storing and keeping the process over the internet. According to National Institute of Standards and Technology (NIST), it is defined as "*a model which permit ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources that can be rapidly provisioned and released with minimal management effort or service provider interaction"* [71]. Since its innovation, it has disrupted many types of field and is constantly changing the landscape of computing service. With the introduction of IoT, Spotify, a music streaming company, has changed the way music is consumed. However, the usage of Spotify demands the use of cloud computing to store its data of the users [72]. Cloud allows the usage of the social service for global users. This will allow for more data for other purposes such as education, storage and business purpose. However, concerns remain. For example, security and privacy of the information stored by Cloud Computing. Thus, study should be done to address the issue.

3.10 Vertical Take-Off and Landing

The final emerging technologies which will be going to be discussed in this work, with the disruptive ability is the autonomous flying vertical take-off and landing (VTOL), which include the Volocopter, a project by a startup company in Germany [73]. It is a continuity of drone concept and allows the passenger to ride in it and navigate autonomously. With the arrival of AV, Volocopter is a development with steps ahead in realizing the idea of smart city implementation. Among the potential benefit of its arrival is no roads will be needed soon with the heavy usage of Volocopter, thus allowing for better traffic and potentially reducing the number of the road vehicle. With the news of Daimler investing 25 Million in the startup Volocopter, the rise of VTOL shown reliable promises [74]. Dubai is planning to have the flying VTOL in the near future, and it is expected to be followed by other countries [75]. Since autonomous VTOL is truly a new design, policymakers need to think about the safety as well as other new policies regarding the creation.

4.0 FUTURE STUDY SUGGESTIONS REGARDING DISRUPTIVE INNOVATION

In previous sections, ten emerging technologies with disruptive ability are briefly viewed and discussed. The high interest of market in investing in these products show a potential of disruptions in near future. Thus, several considerations are required to be given. Due to the 4IR allows for a borderless world, collaborations between academia, industry practitioners and policymakers will expedite the technologies to be benefitted by the society. In addition, among the important study which should be done is the consumer acceptance. This is due to the consumer acceptance play a deep role in the progress of the technology. In addition, the study which should be involved is regarding the new jobs which will be created due to the birth of these technologies. As predicted, 65 percent of children today will work in a still not-existed job field soon [76]. Thus, issue of social implications, security should be studied. In addition, study regarding the new supply chain and trade as well as taxation due to the disruptive innovations should be considered.

5.0 CONCLUSIONS

This work is a review on the current emerging technologies which possess the disruptive ability, which has the potential to change the current technology support network and influence the way of human living. Ten types of emerging technologies were reviewed which include Bitcoin, Autonomous Vehicle as well as Cloud Computing. Several suggestions for future study in relation to the birth of these new technologies are also denoted. Based on the survey, it can be concluded that the arrival of the Fourth Industrial Revolution has directly led to the birth of many emerging technologies which has the disruptive effects. These new innovations will not only create a new technology, but also will disrupt the current Technology Support Network. Thus, this study is important to give the overview of the trend and to stimulate the discussion of these new technologies for Malaysian audience, in particular.

ACKNOWLEDGEMENT

The authors would like to express their appreciation for the Vehicle System Engineering iKohza (VSE) research group in Universiti Teknologi Malaysia, Kuala Lumpur as well as Moovita Pte Ltd in Singapore for their interesting discussions on the emerging technologies.

REFERENCES

[1] Amabile, T. M., Conti, R., Coon, H., Lazenby, J., & Herron, M. (1996). Assessing the work environment for creativity. *Academy of management journal*, *39*(5), 1154-1184.

[2] McLean, L. D. (2005). Organizational culture's influence on creativity and innovation: A review of the literature and implications for human resource development. *Advances in developing human resources*, *7*(2), 226-246.

[3] Christensen, C. (2013). *The innovator's dilemma: when new technologies cause great firms to fail*. Harvard Business Review Press.

[4] Tran, T. (2008). A conceptual model of learning culture and innovation schema. *Competitiveness Review: An International Business Journal*, *18*(3), 287-299.

[5] King, A. A., & Baatartogtokh, B. (2015). How useful is the theory of disruptive innovation? *MIT Sloan Management Review*, *57*(1), 77.

[6] Corsi, S., & Di Minin, A. (2014). Disruptive innovation… in reverse: Adding a geographical dimension to disruptive innovation theory. *Creativity and Innovation Management*, *23*(1), 76-90.

[7] Christensen, C. M., Raynor, M. E., & McDonald, R. (2015) What is disruptive innovation. *Harvard Business Review*, 44-53

[8] Zeleny, M. (2012). High technology and barriers to innovation: From globalization to relocalization. *International Journal of Information Technology & Decision Making*, *11*(02), 441-456.

[9] Gassmann, O. (2006). Opening up the innovation process: towards an agenda. *R&d Management*, *36*(3), 223-228.

[10] Teich, M., & Porter, R. (Eds.). (1996). *The industrial revolution in national context: Europe and the USA*. Cambridge University Press

[11] Schwab, K. (2017). *The fourth industrial revolution*. Crown Business

[12] Kirkpatrick, D. (2011). *The Facebook effect: The inside story of the company that is connecting the world*. Simon and Schuster.

[13] Budget 2018 - Govt to focus on tax incentives for Industry 4.0, The Star (2017) Available Online: https://www.thestar.com.my/business/business-news/2017/07/20/budget-2018---govt-to-focus-on-tax-incentives-for-industry-4pt0/ (accessed 2017.11.05)

[14] Ross, L. (2009). A strategic approach to disruptive technologies.

[15] Heiskanen, E., Hyvönen, K., Niva, M., Pantzar, M., Timonen, P., & Varjonen, J. (2007). User involvement in radical innovation: are consumers conservative?. *European Journal of Innovation Management*, *10*(4), 489-509.

[16] Lucas, H. C., & Goh, J. M. (2009). Disruptive technology: How Kodak missed the digital photography revolution. *The Journal of Strategic Information Systems*, *18*(1), 46-55.

[17] Vuori, T. O., & Huy, Q. N. (2016). Distributed attention and shared emotions in the innovation process: How Nokia lost the smartphone battle. *Administrative Science Quarterly*, *61*(1), 9-51.

[18] Berinato, S. (2010). The iTunes Effect and the Future of Content. *Harvard Business Review. Retrieved July*, *1*, 2014.

[19] Waldfogel, J. (2010). Music file sharing and sales displacement in the iTunes era. *Information economics and policy*, *22*(4), 306-314.

[20] Wlömert, N., & Papies, D. (2016). On-demand streaming services and music industry revenues—Insights from Spotify's market entry. *International Journal of Research in Marketing*, *33*(2), 314-327.

[21] Wayne, M. L. (2017). Netflix, Amazon, and branded television content in subscription video on-demand portals. *Media, Culture & Society*, 0163443717736118.

[22] Yu, Y., Chen, H., Peng, C. H., & Chau, P. (2017). The Causal Effect of Video Streaming on DVD Sales: Evidence from a Natural Experiment.

[23] Sarwar, M., & Soomro, T. R. (2013). Impact of smartphone's on society. *European journal of scientific research*, *98*(2), 216-226.

[24] Church, K., & de Oliveira, R. (2013). What's up with whatsapp?: comparing mobile instant messaging behaviors with traditional SMS. In *Proceedings of the 15th international conference on Human-computer interaction with mobile devices and services* (pp. 352-361). ACM.

[25] Currah, A. (2007). Hollywood, the Internet and the world: A geography of disruptive innovation. *Industry and Innovation*, *14*(4), 359-384.

[26] Fuchs, C. (2007). *Internet and society: Social theory in the information age*. Routledge.

[27] Millard-Ball, A. (2005). *Car-sharing: Where and how it succeeds*(Vol. 108). Transportation Research Board.

[28] Agatz, N., Erera, A., Savelsbergh, M., & Wang, X. (2012). Optimization for dynamic ride-sharing: A review. *European Journal of Operational Research*, *223*(2), 295-303.

[29] Cici, B., Markopoulou, A., Frias-Martinez, E., & Laoutaris, N. (2014). Assessing the potential of ride-sharing using mobile and social data: a tale of four cities. In *Proceedings of the 2014 ACM International Joint Conference on Pervasive and Ubiquitous Computing* (pp. 201-211). ACM.

[30] Katzev, R. (2003). Car sharing: A new approach to urban transportation problems. *Analyses of Social Issues and Public Policy*, *3*(1), 65-86.

[31] Nurvala, J. P. (2015). 'Uberisation' is the future of the digitalised labour market. *European View*, *14*(2), 231-239.

[32] d'Orey, P. M., & Ferreira, M. (2014). Can ride-sharing become attractive? A case study of taxi-sharing employing a simulation modelling approach. *IET Intelligent Transport Systems*, *9*(2), 210-220.

[33] Mei, L. I. N., & DULA, C. W. (2016). Grab Taxi: Navigating new frontiers.

[34] Wirtz, J., & Tang, C. (2016). Uber: Competing as market leader in the us versus being a distant second in china. In *SERVICES MARKETING: People Technology Strategy* (pp. 626-632).

[35] Litman, T. (2014). Autonomous vehicle implementation predictions. *Victoria Transport Policy Institute*, *28*.

[36] Ashton, K. (2011). That 'internet of things' thing. *RFiD Journal*, *22*(7).

[37] Atzori, L., Iera, A., & Morabito, G. (2010). The internet of things: A survey. *Computer networks*, *54*(15), 2787-2805.

[38] Al-Fuqaha, A., Khreishah, A., Guizani, M., Rayes, A., & Mohammadi, M. (2015). Toward better horizontal integration among IoT services. *IEEE Communications Magazine*, *53*(9), 72-79.

[39] How the Internet of Things will change our lives, International Organization for Standardization (2016) Available Online: https://www.iso.org/news/2016/09/Ref2112.html (accessed 2017.11.05)

[40] Hamid, U. Z. A., Pushkin, K., Zamzuri, H., Gueraiche, D., & Rahman, M. A. A. (2016). Current Collision Mitigation Technologies for Advanced Driver Assistance Systems–A Survey. *PERINTIS eJournal*, *6*(2)

[41] California PATH, Partners for Advanced Transportation Technology http://www.path.berkeley.edu/ (accessed 2017.11.05)

[42] Technische Universität Graz – Automated Driving Research https://www.tugraz.at/en/research/fields-of-expertise/mobility-production/automated-driving/ (accessed 2017.11.05)

[43] Smart Mobility Research Center, Tokyo http://web.tuat.ac.jp/~smrc/index.html (accessed 2017.11.05)

[44] Abdul Hamid, U. Z., Zamzuri, H., Yamada, T., Abdul Rahman, M. A., Saito, Y., & Raksincharoensak, P. (2017). Modular design of artificial potential field and nonlinear model predictive control for a vehicle collision avoidance system with move blocking strategy. *Proceedings of the Institution of Mechanical Engineers, Part D: Journal of Automobile Engineering*, 0954407017729057

[45] Samsuri, S. B., Zamzuri, H., Rahman, M. A. A., Mazlan, S. A., & Rahman, A. H. A. (2015). Computational Cost Analysis of Extended Kalman Filter in Simultaneous Localization and Mapping (EKF-SLAM) Problem for Autonomous Vehicle. *ARPN Journal of Engineering and Applied Sciences*, *10*(17), 153-158

[46] Low, C. Y., Zamzuri, H., & Mazlan, S. A. (2014). Simple robust road lane detection algorithm. In *Intelligent and Advanced Systems (ICIAS), 2014 5th International Conference on* (pp. 1-4). IEEE

[47] Zanella, A., Bui, N., Castellani, A., Vangelista, L., & Zorzi, M. (2014). Internet of things for smart cities. *IEEE Internet of Things journal*, *1*(1), 22-32.

[48] Snow Removal on Airfields: Automated Mercedes-Benz Arocs trucks clear the way http://media.daimler.com/marsMediaSite/en/instance/ko/Snow-removal-on-airfields-Automated-Mercedes-Benz-Arocs-trucks-clear-the-way.xhtml?oid=29890415 (accessed 2017.11.05)

[49] Warren, J. D., Adams, J., & Molle, H. (2011). Arduino for robotics. In *Arduino robotics* (pp. 51-82). Apress.

[50] Boys, J. A., Alicuben, E. T., DeMeester, M. J., Worrell, S. G., Oh, D. S., Hagen, J. A., & DeMeester, S. R. (2016). Public perceptions on robotic surgery, hospitals with robots, and surgeons that use them. *Surgical endoscopy*, *30*(4), 1310-1316.

[51] Smith, A., & Anderson, J. (2014). AI, Robotics, and the Future of Jobs. *Pew Research Center*, *6*.

[52] Greenwald, S., Alexander Kulik, André Kunert, Stephan Beck, B. Frohlich, Sue Cobb, Sarah Parsons et al. "Technology and applications for collaborative learning in virtual reality." (2017): 719-726, International Society of the Learning Sciences

[53] Starrs, P. F., & Huntsinger, L. (1995). The Matrix, cyberpunk literature, and the apocalyptic landscapes of information technology. *Information technology and libraries*, *14*(4), 251.

[54] Bendle, M. F. (2005). The apocalyptic imagination and popular culture. *The Journal of Religion and Popular Culture*, *11*(1), 1-1.

[55] Virtual Reality | Definition of Virtual Reality by Merriam-Webster - https://www.merriam-webster.com/dictionary/virtual%20reality (accessed 2017.11.05)

[56] Desai, P. R., Desai, P. N., Ajmera, K. D., & Mehta, K. (2014). A review paper on oculus rift-a virtual reality headset. *arXiv preprint arXiv:1408.1173*.

[57] Vera, L., Herrera, G., & Vived, E. (2005). Virtual reality school for children with learning difficulties. In *Proceedings of the 2005 ACM SIGCHI International Conference on Advances in computer entertainment technology* (pp. 338-341). ACM.

[58] Greenwald, S., Alexander Kulik, André Kunert, Stephan Beck, B. Frohlich, Sue Cobb, Sarah Parsons et al. "Technology and applications for collaborative learning in virtual reality." (2017): 719-726

[59] Nakamoto, S. (2008). Bitcoin: A peer-to-peer electronic cash system

[60] Segendorf, B. (2014). What is bitcoin. *Sveriges Riksbank Economic Review*, *2*, 71-87.

[61] Reid, F., & Harrigan, M. (2013). An analysis of anonymity in the bitcoin system. In *Security and privacy in social networks* (pp. 197-223). Springer New York

[62] Bitcoin's Market Cap Is Now More Than $100 Billion | Forbes https://www.forbes.com/sites/cbovaird/2017/10/20/bitcoins-market-cap-is-now-more-than-100-billion/#6f559942b8bc (accessed 2017.11.05)

[63] Bitcoin – Google Trends https://trends.google.com/trends/explore?date=2015-10-05%202017-11-05&q=bitcoin (accessed 2017.11.05)

[64] Why Bitcoin Matters https://dealbook.nytimes.com/2014/01/21/why-bitcoin-matters/ (accessed 2017.11.05)

[65] Ledger Journal http://www.ledgerjournal.org/ojs/index.php/ledge (accessed 2017.11.05)

[66] Carlozo, L. (2017). What is blockchain?. *Journal of Accountancy*, *224*(1), 29.

[67] McWaters, R., Galaski, R., & Chatterjee, S. (2016). The future of financial infrastructure: An ambitious look at how blockchain can reshape financial services. In *World Economic Forum*

[68] Rengier, F., Mehndiratta, A., von Tengg-Kobligk, H., Zechmann, C. M., Unterhinninghofen, R., Kauczor, H. U., & Giesel, F. L. (2010). 3D printing based on imaging data: review of medical applications. *International journal of computer assisted radiology and surgery*, *5*(4), 335-341.

[69] Stephen Nigro (2016), Three Ways to Reinvent for the Fourth Industrial Revolution, *Forbes* https://www.forbes.com/sites/hp/2016/12/07/three-ways-to-reinvent-for-the-fourth-industrial-revolution/#b8cce215b646 (accessed 2017.11.05)

[70] Rengier, F., Mehndiratta, A., von Tengg-Kobligk, H., Zechmann, C. M., Unterhinninghofen, R., Kauczor, H. U., & Giesel, F. L. (2010). 3D printing based on imaging data: review of medical applications. *International journal of computer assisted radiology and surgery*, *5*(4), 335-341.

[71] Mell, P., & Grance, T. (2011). The NIST definition of cloud computing.

[72] Spotify Moves Itself onto Google's Cloud – Lucky for Google | Wired https://www.wired.com/2016/02/spotify-moves-itself-onto-googles-cloud-lucky-for-google/ (accessed 2017.11.05)

[73] Norris, G. (2016). Urban upstart: four-seat Volocopter development likely key to urban air taxi plan success, says E-volo. *Aviation Week & Space Technology*.

[74] 25 Milion Euros for Volocopter https://press.volocopter.com/?_ga=2.170616486.742788549.1509817099-1357691277.1508496246 (accessed 2017.11.05)

[75] Dubai dreams of flying taxis darting among its skyscrapers | CNBC https://www.cnbc.com/2017/09/30/dubai-dreams-of-flying-taxis-darting-among-its-skyscrapers.html (accessed 2017.11.05)

[76] World Economic Forum. (2016). The future of jobs: Employment, skills and workforce strategy for the fourth industrial revolution. World Economic Forum, Geneva, Switzerland.