The Asian Journal of Technology Management Vol. 13 No. 1 (2020): 16-34

Key Success Factors for 5G Technology Commercialization in Telecommunication Company Case Study of an Established XYZ Company in Indonesia

Sahat Hutajulu*, Wawan Dhewanto, Eko Agus Prasetio, and Priyantono Rudito
School of Business and Management, Institut Teknologi Bandung, Indonesia

Abstract. *Technology commercialization is the long process to bring technology from the research domain into the commercialization area to end-users with monetizing purposes. This study analyzes critical success factors for 5G technology commercialization in an established company in Indonesia. By defining the most significant factors, a company can strategize the most effective investments to important factors only and avoid other less meaningful areas. 5G is approaching fast, and some of the major early adopters Mobile Network Operators (MNO) have already deployed 5G within this year. However, some other MNOs or telecom companies, in general, remain skeptical, considering the wide range of new business cases, the readiness of industries, and twice significant capital investment compare to predecessor technology 4G. This study is based on interpretivism philosophy and uses Qualitative semi-structured in-depth interviews, observation, and deductive scenario planning as the methodology. Use cases, innovation ecosystem, and technology complementary are found to be the key success factors for 5G commercialization in an established company. The novelty of this study is to identify the key success factors for technology commercialization specific for the 5G technology context in Indonesia. Three axes deductive scenario planning using critical success factors as the uncertainties are considered as the originality of this study.*

Keywords: *Key success factors, technology commercialization, established company, 5G.*

1. Introduction

Technology commercialization outlook is changing very fast compared to previous decades. Technology itself is getting complicated and diverse to fulfill human needs. Nowadays, the complexity is further away than just a wood tire to help human transport from one spot to another spot. Technology nowadays is not only emergent but also complex and related to each other.

This study lifts the case of new emergent complex technology, which is 5G. 5G Technology is predicted to be developed in 2020, including in Indonesia (Vora, 2015). Even some countries like the USA, Australia, and South Korea already started the deployment within this year 2019. Just like the previous 4G, implementation of 5G will be nationwide and affecting every level of society. Moreover, with this new 5G implementation, innovations and creativities could occur for people in the dense urban area into a very remote rural area. 5G offers faster data stream (download) than 4G up to 20 times faster (Khan, Minokuchi, Tsubouchi, Kunito, & Iwashina, 2018). Another new feature of 5G is minimal latency into only ten milliseconds about 50 times better than 4G. 5G is also using ultra-higher frequency (3 GHz – 300 GHz), which means more wide frequencies spread, and more devices could be connected into the wireless network (Gopal & Kuppusamy, 2015). With these new ultimate features, many new business use cases should be introduced compare to previous mobile technology.

While some Mobile Network Operators (MNO) and vendors act as innovators and early adopters for 5G technology, some other majority and laggards are still confused about what might be the business use cases nor new revenue streams for 5G (Rogers, 1962). This study is to specify the key success factors for technology commercialization, which

*Corresponding author. Email: sahat.hutajulu@sbm-itb.ac.id
Received: March 23th, 2020; Revised: April 5th, 2020; Accepted: April 17th, 2020
Doi: http://dx.doi.org/10.12695/ajtm.2020.13.1.2
Print ISSN: 1978-6956; Online ISSN: 2089-791X.

companies can be more focused on and inject more investment. By doing this, companies can avoid wasting time, energies, and focus on other factors that are not significant.

Based on the previous explanation, the ultimate research question for this study is to query the key success factors for technology commercialization. The following question is to discuss a possible strategy to act on those critical success factors in technology commercialization. Empirical studies for technology commercialization and semi-structured in-depth interview are done to answer the research questions. This study uses pragmatism as the base philosophy and case study as the research strategy. Five experts in 5G from XYZ Company were consulted to build the key success factors in 2019. Additional two experts in 5G from other companies were also interviewed as the triangulation of data collection. Scenario-based planning is used to build the options of the future and strategies to handle those options, based on the founded key success factors. The novelty of this study is to give an academic contribution in identifying the key success factors specific to the 5G technology context and Indonesian context. This research also provides an additional input in the practical domain by proposing strategies for 5G commercialization in the next future. On the other hand, the originality of this study is to use three axes of uncertainties in deductive scenario planning, which is rarely found in other existing works of literature.

2. Related Literature

Technology commercialization is the process of creating technology from the research institution up to end-users and make it commercial to gain profit. (Aslani, Eftekhari, Hamidi, & Nabavi, 2015). Research institutions could be universities, government research institutes, start-ups, or the established companies. Technology commercialization by an established company has several factors that influence the successes. They are innovation culture, management techniques, capital possibility, networking activities, property rights, scientist personality, organization formation, use case, technology suitability, technology transfer strategy, university policy, and structure, which can be seen in figure 1 as below. (Kirchberger & Pohl, 2016).

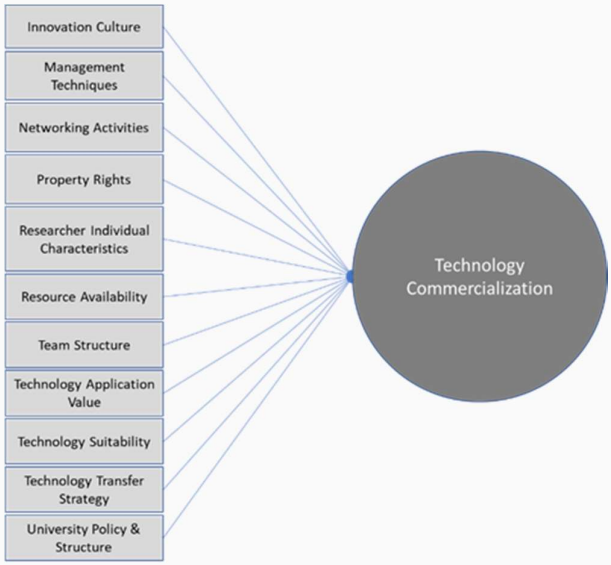

Figure 1.
Literature Review of Technology Commercialization in Established Company (Kirchberger & Pohl, 2016)

Innovation culture (Galbraith, Merrill, & Campbell, 1991; Radosevich,1995) mainly explore innovation in company affecting Technology Commercialization through daily work routines, roots beliefs, and code of conducts. Management Techniques discuss the usage of those techniques for Technology Commercialization, such as risk management, educational database administration, technology prioritizing, penetration spaces, control competence, transmission potency, program administration, and commitment of higher rank management and managers (Galbraith et al., 1991; Neven, 1990). One profound example brought by Wood and Brown (1998) for management technique, which is the managerial decision to place R&D employees directly to the implementation team to deploy the technology. By applying this technique, information flow between the implementation team as end-user ears goes smoothly to the R&D department as a technology formulator. Networking Activities are the interrelation between organizations within the company to support Technology Transfer. Examples are the focus group between the R&D department, and the Engineers department do some knowledge sharing.

Property rights are merely about the patent, and it is proven as one of the success factors for technology commercialization. The reason is that with the property rights and protection by law, less technology imitation would occur. High-level understanding of patent and property rights by CEO and high-level management would increase the technology commercialization positive outcome. (Li, Guo, Liu, & Li, 2008).

Researcher Individual Characteristics is about the researcher her/himself. It is mainly about the motivation they have in mind while doing the research. Some researcher does it because of rewards and some because of additional contribution in the study area. The company can reward the outstanding researcher who invented the technology, which is successfully commercialized with career jump or another monetary benefit (Galbraith et al., 1991). According to Golish et al (2008) about Research Individual Characteristics also proof that the characteristic of the researchers, such as detail process mapping, working extra miles and risk-averse also contributes to the success of technology commercialization.

Resource Availability shows that the availability of resources of the company affecting the technology commercialization. The type of resources is capital, human resources capability, sponsorship by management. Some ideas of technology can quickly die due to no resources available to support the plans. Resources here are including human resources and supporting technologies. Integration by which the company coordinates various resources from different departments in processes, systems, and approach management, is acting as the moderating factor between resource availability and technology commercialization. (Zahra & Nielsen, 2002). Team Structure is about the composition of the team for technology commercialization, which shows the more different the group, the higher is the likelihood of technology commercialization to be successful (Eesley, Hsu, & Roberts, 2013). Diversity in industrial experiences, demography, and individual background functions as the fundamental basement of the team. The number of units and enough set of skills are also affecting the result for technology commercialization (Eisenhardt & Schoonhoven, 1990).

Technology Application Value discusses deeply the more valuable of the technology to end-users, the more likelihood technology commercialization will enhance success. Recognizing and interpreting the end-users needs are essential factors for technology to be successful. (Roberson & Weijo, 1988). Thus, the market survey result from the end-users should be considered as one of the factors to decide which R&D project is selected in an established company. (Slater & Mohr, 2006). Furthermore, company strategies and resources are having a direct link to market segmentation of the

technology. The correct target market and supported by proper company strategies and resources will lead to the success of technology commercialization and business performance. Technology Suitability discusses the properties of the technology itself. Current pieces of literature probe the features of the technology, such as the quality of technique, lifetime, maturity, time to market, outlook, and comprehensiveness. Hence, the involvement of technology inventors in the continuation of product development is required for the success of technology commercialization (Jensen & Thursby, 2001).

The environmental factor acts as a moderating factor for this technology suitability. (Chen, 2009). Technology Transfer Strategy examines the strategy of the company in transferring the technology to the market. The approach is about the transfer method and the commercialization process. The transfer method explains the selection of companies of the technique such as patenting, licensing, strategic alliances, spin-out, joint venture, the new company from university, exhibitions, collective research contracts, consultative services, venture capital, and selling. Joint research contracts and displays are the two most successful technology transfer methods (Aslani et al., 2015). In the commercialization process, however, there is conflicting opinion.

Duhm and Wielockx (1991) said that technology transfer has the best commercialization impact when it is conducted step-by-step process. Contradictory of that is the view from Nevens (1990), who stated that technology transfer should be a highly incorporated system rather than just a step-by-step process. The process of commercialization is divided into four phases. The phases are pre-sales, sales activity, after-sales, and new presales, with activities are done consecutively. The pre-commercialization phase consists of unique technology business team selection, technology application value recognition, new market area research, end-users test, and present in congress or exhibition. The actual commercialization phase, on the other hand, involves activities like real target market definition, business model development, technology adaptation, vendors selection, sales trust propagation, and feedback from customers collection. Post commercialization comprises of flexible business model development, managing supply chain, feedback from customers collection, market area expansion, and new technology application value recognition (re-innovation). The last phase is the new pre-commercialization phase, with the same activities as the pre-commercialization phase. (Gbadegeshin, 2018). On the other hand, previous literature also provides challenges in technology commercialization. The problems are commercialization process shortcomings, business environment conditions, insufficient organizational formation, weak project management, less cooperation with cross-industry sectors, miscarriage stakeholder's partnership and political conflict behavior (Zadeh, Khalilzadeh, Mozafari, Vasei, & Ojaki, 2017).

The Indonesia context is also necessary to be explained in this part. The needs of technology in other countries might be different from the requirements of technology in this country. It is because of Indonesia's nation-specific culture, tradition, situation, condition, social, economy, education, and politic are unique compare to other places. For example, the famous online motorbike transportation in Indonesia could become a huge success, while in other countries cannot. The interest of people in Indonesia is somewhat different, and they respond to technology like marketplace and fintech, for instance, is incredibly unpredictable. The other different thing is the Indonesian technology infrastructure, which is not as mature as a developed country. In a developing country like Indonesia, the physical infrastructure, regulation, and policy, resources such as frequency and humans are not in optimum condition yet. Neither the government involvement in the industry, the readiness of the technology ecosystem in Indonesia. Thus, this research aims to investigate the determinants of technology

commercialization in the Indonesian context, which may bring new theoretical insights that have not discovered previously in the literature.

3. Research Method

This study is based on interpretivism philosophical thinking, which means that the researcher will interpret the conceptual framework from understanding ideas from the respondents (Saunders & Lewis, 2012). Qualitative semi-structured interviews and observations are held to build the model and to analyze the strategy. The respondents are experts from the respective field in the established company who are chosen from different departments to enhance the richness of the data.

Interview protocol is built as a procedure to hold the interview. It is a step by step guideline to make the whole chain of interviews success. (Jacob & Furgerson, 2012).

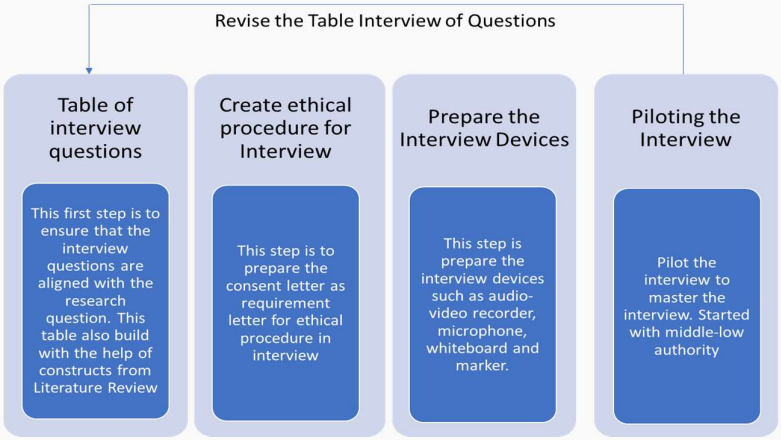

Figure 2.
Interview Protocol

The protocol started with creating the table of interview questions. This first step is to ensure that the interview questions are aligned with the research question. This table is also built with the help of constructs from the Literature Review. The feedbacks are necessary to enhance the quality of interview questions as well as to avoid bias. The bias comes from the dual function of the researcher, who is also a practitioner at the same time. The next step is to get the feedback for the interview plan from other experienced fellow researchers and supervisors. The last preparation step before going into the field is create ethical procedure for interview.

Finally, pilot interview is conducted to a pre-selected person to dig the data as well as to test the whole interview protocol. This pilot interview has capabilities to loop back to first step in interview protocol. From this step, the necessary and unnecessary questions can be identified, whether the consent form is suitable to the respondents, and whether the devices are enough for an interview process. In this research, table interview questions are shortened based on a pilot interview to compact the interview time.

In observation, the researcher is acting as a Complete Participant; it means the researcher is part of the organization but not revealing the purpose of observation activity. However, to avoid being unethical, permission from CEO & CFO already approved to research within the company. Observations were held in the internal news, external news, internal meetings, informal chat with colleagues, canteen chat, and external meetings. This selected observation activity is to collect the purest constructs without being threatened of being researched.

Data collection is conducted to five experts in Telecommunication, as described in Table 1. That table also includes the job position, working experience, duration of the interview, and company of the respondents.

These five persons selected based on their expertise and can be considered as elite interviewing (Marshall & Rossman, 1995). They are believed as individuals who are experts with many high-level exposures in the field and experiences as well as have a broad outlook and time horizon of the topic, organizations, and the implications. They are also selected from different job positions as well as separate areas of working. Even two of the respondents are from outside of the XYZ company. This type of selection is to improve the richness of ideas and data from technical, sales, project, customer, and competitor; instead of getting the data from one similar type of respondents.

Table 1.
List of Respondents

No	Job Position	Years of Experience	Duration Interview	Company
1	Solution Architect	13	45 Minutes	XYZ
2	Account Manager	15	25 Minutes	XYZ
3	Project Manager	10	35 Minutes	XYZ
4	Head Division of Operation	15	25 Minutes	Other (Customer)
5	Solution Architect End to End	15	27 Minutes	Other (Competitor)

The pilot semi-structured in-depth interview is done with a solution architect who has experience for more than 13 years in the telecommunication industry. This first interview was held using the first revision of the interview protocol, which includes a table of questions, consent form, and interview devices. The conversation went for about 45 minutes in a friendly discussion using Bahasa Indonesia, with no extreme emotion that appeared during the interview. Respondents also involved in the small talk during the pause. He seemed not distracted by the break and can answer smoothly to the next questions with his expertise after the stop.

The next interview was held toward the second respondent. He is an Account Manager for Transport Solution with more than 15 years of experience in his field. The respondent once again running well, this time with no interruption. In the second interview, some of the questions in the table of items were not stressed. The problems even improvised to dig deeper into the constructs. This activity was to avoid repetitive ideas or constructs compare to the pilot interview and to probe for differences between the first and second respondents when their answers were almost the same. This effort evaded the discussion from another interruption.

The third interview was held with a Project Director and was a Solution Architect, which means he is equipped with technical knowledge as well as a business matter. The meeting happened for about 35 minutes, with no interruption. Compare to the pilot, and second, this third interview was smoother. The questions were stressed more to certain constructs, to probe more to the new constructs mentioned as the answer.

For data triangulation, two additional respondents are chosen to be interviewed. The respondent is an expert in mobile telecommunication for more than 15 years, with various backgrounds such as engineer, designer, solution, manager, head of the solution, and head of the operation. This

attempt is to give a broader approach and dialectical for data contributions of this study. It is also to neglect the monism of the data due to the case study of a company.

Observation data were gained from the internal websites, social media of the companies, internal meetings, informal discussions, as well as canteen chit chat. The data collection is to search for the strategy of the company to respond to those critical success factors as a result of the interview.
Following the strategy formulation from observation data, scenario planning is used to make the strategy more practical. Scenario Planning is defined as tool or discipline methodology to see several feasible states in the forthcoming time to create strategic planning and decision making of an organization. (Porter, 1980; Ringland & Schwartz, 1998; Schoemaker, 1995; Scwartz, 1991). It is, indeed, a powerful tool for leaders and stakeholders to make environmental, societal, and economically friendly, reasonable, and practical planning and strategies. One of the most popular uses of scenario planning is the Shell Scenarios. The company develops many future scenarios for a global, regional or individual country, where the decision-makers such as governments, entrepreneurs, academicians, and elites work together to foresee, plan and act for a better future up to 30-50 years in front. Scenario planning can work for energy reservations, Disease action, and prevention and encounter future technologies (Shell, 2017).

Scenario planning is dealing with uncertainties, something which is still in question mark typically in the future. This methodological tool requires people from many perspectives and disciplines to look at that uncertainties and create options for future states (Shell, 2013). Those uncertainties then converted as key drivers. Scenarios then are build based on those key drivers, which are representing favorable strategy against non-favorable strategy (Kublik, Stones, von Glischinski-Kurc, Kang, Borggreve, & Whysall, 2017)

There are four variations of methods in building scenario planning; they are inductive, deductive, incremental, and normative (Hanafizadeh, Hashemi, & Parvin, 2009) and (Thomas, 2014). This study will use the deductive scenario planning, which crosses axes of uncertainties and eventually create options for future scenarios. For example, axis x is representing uncertainty one, and axis y is representing uncertainty two. Constellation diagram will be formed with four scenes that are created as possible future states, as seen in figure 3 below.

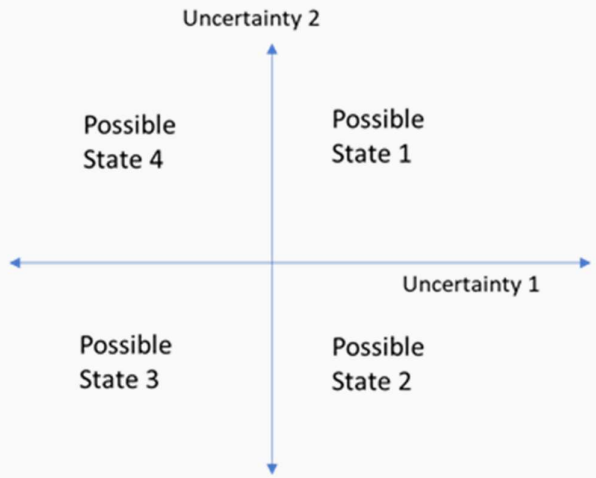

Figure 3.
Deductive Scenario Planning with Two Uncertainties

4. Analysis

Data from interviews and observations are analyzed using mind mapping. It is a procedure to divide the constructs from the respondents into different categories (Taylor-Powell & Renner, 2003). The classes are sub-sub category, subcategory, category, and super-category. The super-category is the highest order or generalization; in this case, it is technology commercialization itself. Category, subcategory, and sub-sub category are lower orders in generalization or even real examples of the constructs. Each respondent has their mind mapping tables.

An analysis is also done for observation data using the same mechanism of mind mapping, as shown in Table 2. It is also shown that the results are categorized into the sub-sub category, subcategory, category, and super-category. Based on the observations, mind mapping is created to classify the strategies of the company in handling the critical success factors.

Table 2.
Mind Mapping Result of Observations

Super Category	Category	Subcategory	Sub-Subcategory
Use Cases	Marketing Strategy	Showcase & Exhibition	5G Showcases
			Barcelona Exhibition
	Customer Investment	Direct Network Engagement	5G Demo
			5G Trial
	Technology Education	End Users Education	Video for End Users
Innovation Ecosystem	Ecosystem Cooperation	Ecosystem Cooperation	5G Garage
			IoT Garage
		Ecosystem Nudging	5G Start-Up Competition
	Ecosystem Maintenance	Relationship Maintenance	Updates to Government
			University to R&D Tech Transfer
Complementary Technology	Business Endeavour	Direct Business Cooperation	Cooperation with Vodafone & Oppo
	Technologies Interoperability Lifecycle	Technology Testing	Remote Excavator Testing
			Holographic Video Call
		Impact on Other Technology	AI Development

Key success factors for technology commercialization are taken from mind mapping interview results while the strategy of marketing & investment is gained from observation mind mapping.

5. Finding and Discussion

The result of the in-depth semi-structured interviews is the three critical success factors for technology commercialization. Those three are use cases, innovation ecosystems, and complementary technology. These three constructs were the answers from the respondents for the main question during the interview. They are all also mentioned and stressed a lot during the other part of the discussion. When the question was asked to the Solution Architect about the most critical factor for technology commercialization, the answer is the technology application.

"In my opinion, based on my experiences, the key is application. Sometimes for devices or technology, in the end, they will be questioned, what use they will bring. This new use case must be invented. Thus, many create an incubator, 5G garage, work with Singapore Polytechnic. Else, there is an IoT garage so that people can create use case applications. If not created, why should I create a device or technology? The same with XYZ company, what are the benefits of inventing technology if no one uses it."

From the above answer, it can be inferred that the use case is the most critical factor for technology commercialization. This is aligned with previous research that Technology Application Value, which translated as the goodness of technology to human life, is one of the distinctive factors for technology commercialization (Kirchberger & Pohl, 2016). At the same time, the participant mentioned the example of an innovation ecosystem such as 5G garage and IoT garage. These are forms of examples of the innovation ecosystem, which consist of established companies, Government, University, Incubator, and Start-up (Natarajan, Hedge, & Ramalingegowda, 2019; Yole Development, 2017). The source also stated that technology complementary as an important factor for 5G commercialization. The technology examples are IoT, AI, Holographic Call, Real-Time Controlling, and Autonomous Vehicle.

Another participant, the account manager, stated that crucial success factors for 5G would be different from previous technology 4G. He stressed in his statement that the offer of new emergent technology like 5G should be varied from predecessor technology like 4G. In smart city cases, the latest offers in 5G vary from e-Health, Smart Industry, Smart Grid, IoT and Sensors, City Surveillance, Virtual Reality, Agriculture 2.0, and Smart Safety (Marabissi et al., 2019). These services are not existing or very limited to 4G technology.

"In my opinion, it must be different. If in 4G commercialization attempt only to offer data package, what will be offered in 5G with that huge additional download speed? Could be used to remote drive car from a distance using a cell phone, with no delay, possible. But it will depend on use cases created by the industries. It is not necessary that Mobile Network Operator that create the use case. Another industry may create its use cases."

From the participant explanation above, it echoes the importance of use cases in the commercialization activity. This time, the expert compared it with previous technology and stated that the use cases of technology should be different. Otherwise, it will not do much, and people prefer to choose previous cheaper technology. The participant also mentioned about other industry players as an additional use case creator in the innovation ecosystem. In China's case, this cross-industry 5G innovation center was launched in February 2016 as an initiative of China Mobile, and have generated innovative new services, products, projects, revenue streams for around 112 cross-industry players (Huang et al., 2017).

The third expert focuses more on technology complementary. He had self-experience when the technology complementary did not exist; it is tough for him to promote or even sold the new emergent technology.

There are two critical factors for technology to be sustainable. The first is the ecosystem, and the second is the use case. Ecosystem means telecommunication technology is not stand alone, but more a holistic technique. Those technologies should be developed together to become one right integral technology. For example, LTE (4G), when the first time came in Indonesia, was driven by Mobile Network Operator—developed by a 3GPP standardization body, which released new emergent technology standard recommendations. But the streaming process will never succeed if the ecosystem does not support it. For example, it is the device or cell phone. When 4G arrived in Indonesia, the plot was tough to found. When I first deployed the 4G for an MNO, the modem is

also hard to found. This kind of thing will affect the growth and development of new emergent technology.

The third expert, despite seating in the different interviews, also stressed the same critical success factors for 5G technology commercialization, which is technology complementary. This is parallel with Industry 4.0 concept that new emergent technologies are corresponding to each other's, including 5G (Baldassarre, Ricciardi, & Campo, 2017). Complementary technology is not just about the techniques but also related to managing the technologies, interoperability and the lifecycle together (Oztemel & Gursev, 2018)
The richness of the data was added from other respondents outside of the XYZ organization. They are also an expert in mobile telecommunication company with depth experiences. During the interview, one expert stressed the three most important factors for 5G commercialization; they are demand from the customer, cost efficiency within the company, and industry 4.0.

What is the demand growth traffic compare to an existing resource, better to use existing support rather than deploy new technology? However, for a dense area where additional sites are nearly impossible, new technology such as 5G could be one option for cost efficiency. For industrial 4.0, the applications of industrial 5G should be cheaper compare to the manual worker.

Demand from a customer means the need to use the technology, as respondent mentioned the market is the growing traffic of data call. In other words, customer craving for application value which can fulfill the necessity. Besides, Industry 4.0 is closely related to the innovation ecosystem; it is the condition when many technology companies collaborate in providing solutions for cross-industries (Elayoubi et al., 2017).

Echoing the answers from previous respondents, the last respondents, who are the End-to-End Solution Architect, mentioned that the critical success factors for 5G technology commercialization are a campaign of 5G use case. For example, it is the drive for a 5G use case, Fixed Wireless Access. The stressed is the specific campaign to rural or even remote area, that those societies can-in the near future-connected with 5G just as urban communities enjoy the optical broadband internet services. The respondent also mentions about innovation ecosystem, with the specific practical example of IoT laboratories for Indonesia.

Based on the participant's answers, it can be concluded that the key success factors for 5G technology commercialization are technology complementary, innovation ecosystem, and the technology application value (use cases). The illustration of crucial success factors for 5G commercialization is shown in Figure 4.

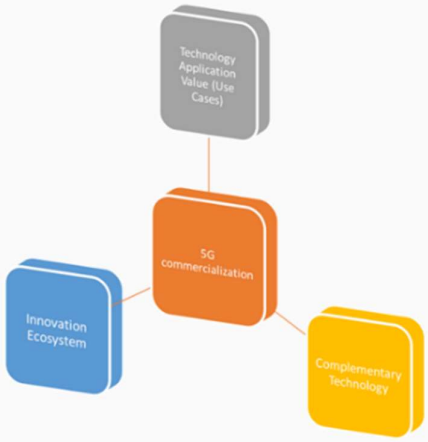

Figure 4
Key Success Factors of 5G Technology Commercialization for Established Company

The use cases mean the usage of technology for end-users and values, which are brought by the technology to ways of living in society. This notion is including business use cases, perceived usefulness, adoption of technology, user expectations, technology experience, consumer thoughts, and demands (Kirchberger & Pohl, 2016). In 5G case, the business cases are spread in Highspeed Download, Augmented Reality/Virtual Reality (AR/VR), Fixed Wireless Access, Hologram Teleconference, Internet of Things (IoT), Remote Excavator or Health Operation (Tudzarov & Gelev, 2017). Those business cases are closely related to the usefulness in daily life for end customers as well as the usage of technology in the regular operation of business and industries.

Innovation Ecosystem means cooperation, co-creation, and networking of many entities of technology to bring more innovations and values (Miller et al., 2009). Substances that are defined here as including established technology company, mobile network operator, government, university, incubator, start-up, technology associations, and other related entities (Carayannis & Campbell, 2009). The ecosystem is well known as the extension of supply chain entities, which believed that all stakeholders are involved in creating value to end customers even though the objects are not in the chain. In the 4G case, an example of the innovation ecosystem is the online distribution for farmers, online transportation, etc. which innovate new business cases and enhance the use of 4G.

Complementary Technology is the other technologies that are used together to be used by end-users to create meaning. In the 5G case example, they include 5G handphones, Internet of Things, 5G devices, Autonomous Vehicles, Dynamic Advance Robotic, Taxi Drone, and even Nano Technology or Semiconductor Technology. Nowadays, technologies are related to each other's, and the complement of those technologies creates new values and meaning to human life (IFTF, 2019).

If we compare figure 1 and figure 4, then the conclusion can be pulled from the comparison of literature review versus findings in this study. The use case in the results of this study is the same meaning with technology application value from the literature review. However, the innovation ecosystem and complementary technology are considered as relatively new as factors in technology commercialization. This is understandable because the world is rapidly evolving, and the ecosystem to innovate is becoming an excellent capital for human life—the same works for complementary technology. Now, like many things, industries and domains can be connected, technologies need to be complemented between one and another. For example, to connect industries such as agriculture, health care, and finance at the same time, there should be technologies complementing each other to make it work.

Based on the key success factors above, observations were made to query on the strategies of the company to work on founded constructs. From the observations, it is known that the three key success factors use cases, innovation ecosystem, and complementary technology are closely related between each other. When one talks about the use cases in new emergent complex technology, it must involve other technologies to be the complements until they finally can bring value to end-users. The involvement of other technologies automatically includes other entities such as other companies, start-ups, incubators, governments, or universities within the ecosystem (Santos & Eisenhardt, 2005).

From table 2 observation, mind mapping, the strategy of the company to promote the use cases are through marketing strategy, investment to customer premises, and technology education. On the other hand, the procedure related to the innovation ecosystem is ecosystem cooperation and ecosystem maintenance. For the last success factors of technology complementary, the company involved other companies of different technology in being in a business project as

well as together create the lifecycle for that technology interoperability lifecycle.

In advertising use cases of new emergent technology, they established company need to linked first their technology adequacy to marketing strategy. This is to ensure the integrity of internal capability and selling point to the customer (Suharto, 2014). After that company can use marketing strategy, customer investment, and technology education (Meyers, 2009), in marketing strategy, a company can choose the form of showcase or exhibition to attract all the supply chain-related entities and primarily the end-users. Through that activities, those entities can see by themselves what the technology can do to their live and decide whether to adopt it. In a different circumstance, company can go for trial or demo for direct contact in customer premises, to explain the technology even more (Gbadegeshin, 2018). For example, as stated in one of the informal discussions, "5G trial in Operator network which can show them the value of the technology and new revenue streams which can be generated due to this new technology". Another effort which can be created by an established company is to educate the entire supply chain, especially end-users, through formal or informal education platform such as the university, school, social media, and CSR program.

One respondent, who is the End-to-End Solution Architect, even has quite an extreme argument about the method of the marketing strategy of 5G commercialization.

"We should start to strengthen our campaign. The campaign should be more than just demo, showcase, or exhibition in big cities or urban areas, the campaign should be held in rural or even remote area, so that those societies can enjoy the new services of 5G. For example, is LTE or 5G to the home. This campaign can be done directly on-site in the rural area and make it semi-permanent. This kind of campaign can help the government and societies to look at the proof of 5G directly. This example of 5G to the home or Fixed Wireless Access, has also been used in Australia. Can you imagine a cluster of societies now can connect to the Internet."

Innovation Ecosystem is a relatively new terminology in this high-speed changing technology. This term is replacing the supply chain to explain the unique relationship of entities that cannot be revealed before. Such as relation of business with the university, start-up, government even to another ecosystem (Teece, 2007). Examples of the innovation ecosystem are the common platform and environment, which is open and can be used by whoever wants to test the innovation. In Singapore's case, the 5G garage is introduced as the co-innovation between Singtel, Singapore Polytechnique & Ericsson (Singtel, 2019). The support from other entities in the ecosystem, such as established companies and government are also the primary key. That affiliation between entities in the ecosystem should be in continuation and evolvement and not just a cross-sectional timeline (Moore, 1993). In the case of XYZ company, the innovation ecosystem could be achieved by creating a 5G Start-Up competition for students. This activity itself already involves many 5G actors, relatively low-cost, and agitate the innovation in 5G.

One of the respondents has mentioned one of the practical examples in the innovation ecosystem in Indonesia. "The idea is to create the Habibie Center and end to end ecosystem for technologies in Indonesia. Here, hopefully, a lot of local IoT players come out with creativities and create new use cases. The technologies are there. Thus, the local IoT players could invent new creativities by connecting those technologies.". The bottom line is the innovation ecosystem can benefit even the least innovative small company, cultivate that company, and have a bigger chance to become the leader in that field. The government, on the other hand, should maintain that innovation ecosystem to be always fruitful for all the members of the chamber. (Teja, 2017)

Complementary Technology lies in the fact that new emergent technology could be maximized to bring more value to end-users by joint development partners (Siegel, Hansen, & Pellas, 1995). In the case of 5G, this technology is the tunnel of data communication, which is very high speed. However, at least someone needs 5G handset to enjoy the technology finally. In other use cases, it will need, Internet of Things, Artificial Intelligence, Autonomous Vehicles, Augmented Reality/Virtual Reality, Advanced Robotics, and some other complex technology (Tudzarov & Gelev, 2017). To promote these key success factors, a company could do testing or demo, which combines several technologies. For example, remote excavator testing, holographical call, and remote surgery, which can lead to new business revenue streams. To maintain these related technologies can work together, a new technology lifecycle should be created a part of each technology lifecycle. This new lifecycle should make sure the interoperability always works even in future development. Co-creation of one-page lifecycle development technologies between companies, such as 5G, IoT, and healthcare equipment, could be one powerful commercialization exercise to hospitals.

To prepare the telecommunication companies with options of strategies, as well as being resilient in facing 5G, a deductive scenario planning is constructed based on the pre-defined key success factors. The illustration for the scenario planning is shown in Figure 5 as below.

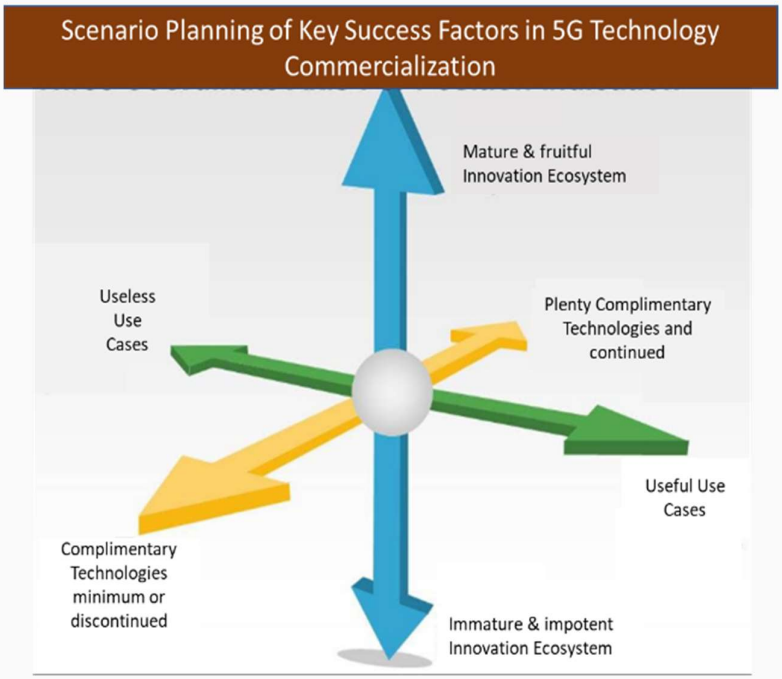

Figure 5.
Three Axes Scenario Planning for 5G Technology Commercialization

The scenario planning consists of three axes, which are the critical success factors themselves, Use Cases, Innovation Ecosystem, and Complementary Technologies, which treated as uncertainties (Shell. 2013). Each axis stretched from favorable conditions to non-favorable conditions. Use case axis lies from useful use cases in a positive domain to useless use cases in a negative area. On the other hand, the innovation ecosystem span from a mature & fruitful ecosystem to an immature & impotent ecosystem. Complementary Technology axis spread from existing & continued until non-exist & discontinued (Kublik et al., 2017).

From the above 3-axes scenario planning, eight areas are constructed (Hanafizadeh et al., 2009). The areas refer to conditions when all three KSFs are favorable, only two KSFs promising, and one is non-favorable, only one KSF is favorable, and two are non-favorable, all three KSFs are non-favorable. Each condition can then be linked to the strategy from mind mapping in Table 2.

The complete analysis of the areas, conditions, and strategies can be seen in Table 3 below. The table shows eight (8) scenarios in the future with a combination of favorable and non-favorable of use cases (UC), innovation ecosystem (IE), and Technology Complementary (TC).

Table 3.
Areas, Conditions and Reasonable Strategies

No	Areas	Conditions	Reasonable Strategies
1	UC (+), IE (+), TCP (+)	Ideal condition when UC, IE & TCP are favorable and supporting the TC	Maintain the running strategies (investment, marketing, sales & educational), cultivate good relationship with actors in ecosystem and conserve co-working with other TCP companies. This condition should bring optimum business value to company.
2	UC (+), IE (+), TCP (-)	Condition when UC & IE are favorable, but TCP is minimum and discontinued	In this condition, company should maintain the UC & IE, whilst at the same time, instead of waiting, seek for cooperation with other TCP companies. It can be from inside/outside the country. Creating simple TCP can also be short term solution.
3	UC (+), IE (-), TCP (+)	Condition when UC & TCP are favorable, but IE is immature and impotent.	In this condition, company should maintain the UC & TCP, whilst at the same time, proactively pioneer and nurture the ecosystem. The main goal is to create fruitful innovation ecosystem. Company can select team to work on this matter.
4	UC (-), IE (+), TCP (+)	Condition when IE & TCP are favorable, but UC is useless.	In this condition, company should maintain the IE & TCP. At the same time should address the homework or creating useful UC. Company should conduct re-research internally and create basic useful use cases which invented by the company itself.
5	UC (+), IE (-), TCP (-)	Condition when only UC is favorable, but IE & TCP are immature & minimum.	In this condition, company should maintain the UC, to at least maintain the basic revenue. At the same time company should focus and put energies on TCP and IE, so that additional & innovative use cases could be birth.
6	UC (-), IE (+), TCP (-)	Condition when only IE is favorable, but UE & TCP are useless & minimum.	In this condition, company should maintain the IE. At the same time should address the homework or creating useful UC. And, instead of waiting, seek for cooperation with other TCP companies or creating simple TCP for short term solution. (Unlikely to happen)

7	UC (-), IE (-), TCP (+)	Condition when only TCP is favorable, but UE & IE are useless & immature.	In this condition, company should maintain the IE. At the same time should address the homework or creating useful UC. And also, at the same time, proactively pioneer and nurture the ecosystem. (Unlikely to happen)
8	UC (-), IE (-), TCP (-)	Most non-ideal condition when three KSFs are non-favorable.	This can be considered as initial condition. In case this condition remains for quite sometimes, company should reconsider to continue the technology commercialization or drop it to be more focus on different technology.

UC: Use Cases, IE: Innovation Ecosystem, TCP: Technology Complementary

From the above table, telecommunication companies could reflect their real conditions and select which areas they are now. Right strategies could be produced when the companies realize and do the competence analysis honestly in their state (Datta, 2011). By knowing their conditions, they can plan towards which direction the strategy will move in several years ahead. At the same time, the company can create back up plans if the policies are not working as planned.

For example, a company starts at area number 8; when use cases are useless, the innovation ecosystem is immature & impotent, and technology complementary is minimum. This state can be considered as a real condition, typically initial year when a company decided to start the technology commercialization. It is quite a real initial condition for Indonesia's case since now, the use cases for 5G is not clear yet. The innovation ecosystem of 5G technology is either in premature condition with a lack of involvement of government, universities, established companies, nor associations. Neither the complementary technology for 5G, such as handsets, IoT, artificial intelligence, and augmented/virtual reality, is minimal nowadays.

The company then can plan within one year, the condition change to area number 5 or the use case will be useful for the customers. This can be achieved through investment, marketing, sales, people, and other strategies (Gbadegeshin, 2018). Then in 2nd year, the company targets the cooperation with complementary technology companies to create additional value products/services/solutions or new use cases to customers or area number 3. In this period, the company can also enhance the marketing innovation to the product, such as innovation for product design, price, product place, and promotion (Ismudiar & Rufaidah, 2016). Lastly, the company targets to be in ideal condition number 1 when the innovation ecosystem should already be mature and fruitful in 3rd year.

Plan B for the above master strategy could be created if, somehow, the company finds an unexpected outcome in the future. For example, the company could move from area 8 to area 5 in 1st year, but then it fails to move to area 3 in 2nd year, then the company could choose to re-route the move to area 2 instead. Then finally move to area 1 in 3rd year. Or as simple as, add one more year if the company could not achieve area 2 in sophomore year. The illustration of the initial plan and back up plans can be seen in Figure 6 as below. The decision to move from one area to another area depends on the resources of the company, internal discussion and agreement, and real field conditions of KSFs.

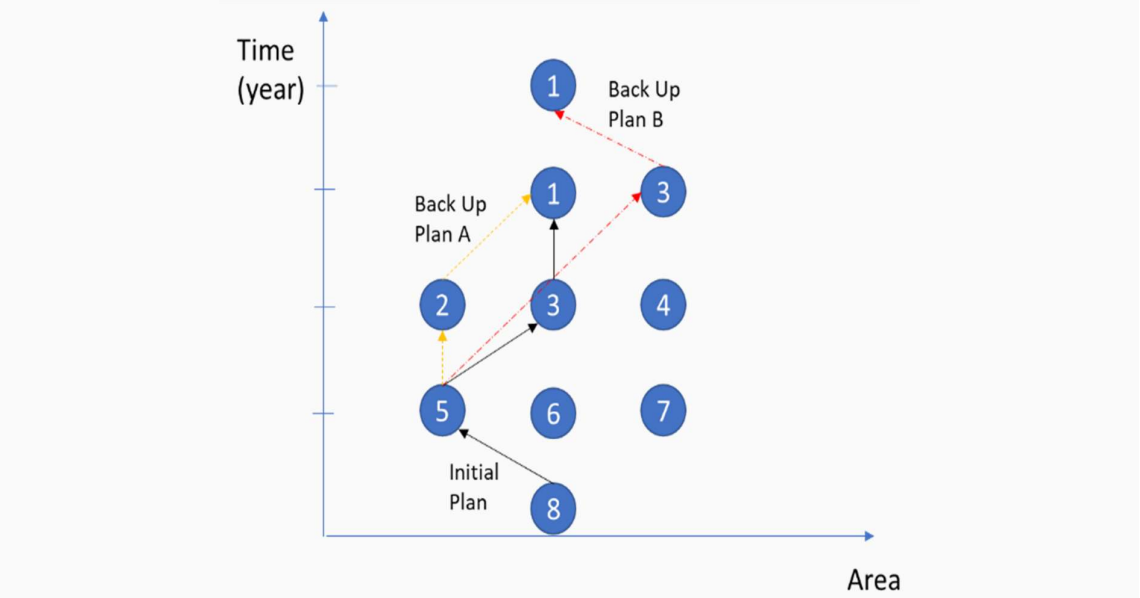

Figure 6.
Initial Strategy Plan and Back-Up Strategy Plans

The above pattern in Figure 6 is suitable for the argument of one respondent who is the Head of Operation. The case states that most likely, 5G will be firstly used for data call (area 5) for several years. Then after that, slowly moving to IoT (area 3) before finally cross-industries or industry 4.0 comes in place to offer value to industries (area 1).

5. Conclusion

Technology commercialization is the end to end process of creating value of the technology from research and development domain up to end-users, following the supply chain or ecosystem flow. This study is to understand the key success factors of new emergent technology, which is built by an established company. This qualitative study using a semi-structured interview results in three vital key success factors, which are the use cases, innovation ecosystem, and technology complementary.

An established company can promote the use of cases of new emergent technology using the marketing strategy, customer premises investment, and technology education. For the innovation ecosystem, an established company can make an effort to co-innovate in an ecosystem as well as to maintain the ecosystem affiliation. To leverage the technology complementary, established companies can create new business between those technology companies with a combination of technologies. Those companies should also create a co-lifecycle that ensures the interoperability of technologies in the current state as well as future development.

Scenario planning is constructed in this study to provide optional strategies based on the conditions of each key success factors. Eight conditions can be generated from three-axes scenario planning, and each situation is a desirable state of the company. The company can practically create a real master strategy to achieve each condition in time (year) span and create the backup plans.

This study has proven claimed for novelty and contribution both in the academic domain and the working world. However, some recommendations can be generated for the next research in the future. The number of respondents is just five (5) respondents due to this is only a preliminary study. Additional respondents need to be added to justify the

constructs until saturation is achieved as no new construct generated from the interview. Focus Discussion Groups could be used as an additional tool to construct the model and to minimize the data collection time. More Observation & public data mining could also be used for data collection methodology to justify the generalization of the constructs, which are built in this study.

References

Aslani, A., Eftekhari, H., Hamidi, M., & Nabavi, B. (2015). Commercialization methods of a new product/service in ICT industry: Case of a science & technology park. *Organizacija, 48*(2), 131-138.

Baldassarre, F., Ricciardi, F., & Campo, R. (2017). The Advent of Industry 4.0 In Manufacturing Industry: Literature Review and Growth Opportunities. Dubrovnik: University of Dubrovnik. Retrieved from https://search.proquest.com/docview/2068860672?accountid=31562

Carayannis, E. G., & Campbell, D. F. (2009). 'Mode 3'and'Quadruple Helix': toward a 21st century fractal innovation ecosystem. *International journal of technology management, 46*(3-4), 201-234.

Chen, C. J. (2009). Technology commercialization, incubator and venture capital, and new venture performance. *Journal of Business research, 62*(1), 93-103.

Datta, A. (2011). *Essays on technological innovations: Commercialization and radicalness* [Doctoral dissertation, Washington State University]

Duhm, E. J., & Wielockx, A. (1991). From research to volume production. International *Journal of Technology Management, 6*(1-2), 123-130.

Eesley, C. E., Hsu, D. H., & Roberts, E. B. (2013). The contingent effects of top management teams on venture performance: Aligning founding team composition with innovation strategy and commercialization environment. *Strategic Management Journal, 35*(12), 1798–1817.

Eisenhardt, K. M., & Schoonhoven, C. B. (1990). Organizational growth: Linking founding team, strategy, environment, and growth among U.S. Semiconductor ventures, 1978–1988. *Administrative Science Quarterly, 35*(3), 504-529.

Elayoubi, S., Bedo, J.-S., Filippou, M., Gavras, A. Giustiniano, D., … Tjelta, T. (2017). 5G innovations for new business opportunities. *Mobile World Congress, Feb 2017, Barcelone, Spain.*

Galbraith, C. S., Merrill, G., & Campbell, K. (1991). The vertical transfer of technological know-how in the navy research and development community. *The Journal of High Technology Management Research, 2*(1), 15–33.

Gbadegeshin, S. (2018). Lean Commercialization: A New Framework for Commercializing High Technologies. *Technology Innovation Management Review, 8*(9),50–64.

Golish, B. L., Besterfield-Sacre, M. E., & Shuman, L. J. (2008). Comparing academic and corporate technology development processes. *Journal of Product Innovation Management, 25*(1), 47-62.

Gopal, B. G., & Kuppusamy, P. G. (2015). A comparative study on 4G and 5G technology for wireless applications. *IOSR Journal of Electronics and Communication Engineering, 10*(6), 67-72.

Hanafizadeh, P., Hashemi, A., & Parvin, E. S. (2009). Robust strategic planning employing scenario planning and fuzzy inference system. *International Journal of Decision Support System Technology (IJDSST), 1*(3), 21-45.

Huang, Y., I, C.-L., Yang, G., Yu, J., Shen, X., & Li, K. (2017). Adding Value to 5G Ecosystem. (n.d.). Retrieved from https://futurenetworks.ieee.org/tech-focus/december-2017/adding-value-to-5g-ecosystem.

Institute for The Future (IFTF). (2019). 20 Combinatorial Forecasts: The Technology Horizon. Retrieved from http://www.iftf.org/maps/20-combinatorial-forecasts.

Ismudiar, W. K., & Rufaidah, P. (2016). Marketing Innovation on Personal Electronic Products. *The Asian Journal of Technology Management, 9*(1), 37-51.

Jacob, S. A., & Furgerson, S. P. (2012). Writing interview protocols and conducting interviews: Tips for students new to the field of qualitative research. *The Qualitative Report*, 17(6), 1-10.

Jensen, R., & Thursby, M. (2001). Proofs and prototypes for sale: The licensing of university inventions. *American Economic Review, 91*(1), 240-259.

Khan, A., Minokuchi, A., Tsubouchi, K., Kunito, G., & Iwashina, S. (2018). Technology and Standards Accelerating 5G Commercialization. *IEICE Transactions on Communications, e102–b*(3), 410-417.

Kirchberger, M. A., & Pohl, L. (2016). Technology commercialization: a literature review of success factors and antecedents across different contexts. *The Journal of Technology Transfer, 41*(5), 1077-1112.

Kublik, F., Stones, A., von Glischinski-Kurc, M., Kang, C., Borggreve, A., & Whysall, J. (2017). *Shell Energy Scenarios Germany* [Brochure]. Germany: Royal Dutch Shell Plc.

Li, Y., Guo, H., Liu, Y., & Li, M. (2008). Incentive mechanisms, entrepreneurial orientation, and technology commercialization: Evidence from China's transitional economy. *Journal of Product Innovation Management, 25*(1), 63–78.

Marshall, C., & Rossman, G. B. (2014). *Designing qualitative research*. London: Sage publications.

Marabissi, D., Mucchi, L., Fantacci, R., Spada, M. R., Massimiani, F., Fratini, A., ... & Fedele, L. (2019). A real case of implementation of the future 5G city. *Future Internet, 11*(1), 4.

Meyers, A. D. (2009). Commercialization of innovative technologies: Bringing good ideas to the marketplace. *Journal of Commercial Biotechnology, 15*(4), 374-375.

Miller, G. T., Spoolman, S. E., Malatesta, K., Yip, L., Marinkovich, A., Hugel, R., ... & Ciemma, R. (2009). Living in the Environment: Concepts, Connections, and Solutions, 16e. *International Student Edition. Belmont: Brooks/Cole, Cengage Learning*.

Moore, J. F. (1993). Predators and prey: a new ecology of competition. *Harvard business review, 71*(3), 75-86.

Natarajan, P., Hedge, V., & Ramalingegowda, C. (2019, Feb 26th). 5G Technology: The Future of Connectivity. Retrieved from https://zinnov.com/5g-technology-the-future-of-connectivity/.

Nevens, T. M. (1990). Commercializing technology: What the best companies do. *Planning Review, 18*(6), 20–24.

Porter, M. (1980). *Competitive strategy*. New York: Free Press.

Oztemel, E., & Gursev, S. (2018). Literature review of industry 4.0 and related technologies. *Journal of Intelligent Manufacturing*, 31, 127-182.

Radosevich, R. (1995). A model for entrepreneurial spin-offs from public technology sources. *International Journal of Technology Management, 10*(7–8), 879–893.

Ringland, G., & Schwartz, P. P. (1998). *Scenario planning: managing for the future*. John Wiley & Sons.

Roberson, B. F., & Weijo, R. O. (1988). Using market research to convert federal technology into marketable products. *The Journal of Technology Transfer, 13*(1), 27-33.

Rogers, E. M. (1962). *Diffusion of Innovation 4th Edition*. Free Press.

Santos, F. M., & Eisenhardt., K. M. (2005). Constructing markets and organizing boundaries: Entrepreneurial action in nascent fields. *Working paper, INSEAD*.

Saunders, M. N., & Lewis, P. (2012). *Doing research in business & management: An essential guide to planning your project*. Harlow, England: Pearson.

Schoemaker, P. J. (1993). Multiple scenario development: Its conceptual and behavioral foundation. *Strategic management journal, 14*(3), 193-213.

Schwartz, P. (1991). *The Art of the Long View: Paths to Strategic Insight for Yourself and Your Company*. New York: Doubleday.

Shell (Producer). (2017, December 11th).

Navigating an Uncertain Future [Video file]. Retrieved from https://www.youtube.com/watch?v=nwub4Bhr-aM in 10th July 2019 at 15:50.

Shell (Producer). (2013, June 4th). *Impact and Influence* [Video file]. Retrieved from https://www.youtube.com/watch?v=3nuPYPllBuw in 10th July 2019 at 15:50.

Siegel, R. A., Hansen, S., & Pellas, L. H. (1995). Accelerating the commercialization of technology: Commercialization through co-operation. *Industrial Management & Data Systems, 95*(1), 18-26.

Singtel. (2019). 5G Garage. (n.d.). Retrieved from https://www.singtel.com/business/products-services/mobility/5g-garage.

Slater, S. F., & Mohr, J. J. (2006). Successful development and commercialization of technological innovation: Insights based on strategy type. *Journal of product innovation management, 23*(1), 26-33.

Suharto, Y. (2014). Linking Technology Capabilities to Marketing Requirements: Case of Indonesian Aircraft Industry. *The Asian Journal of Technology Management, 7*(1), 9-18.

Taylor-Powell, E., & Renner, M. (2003). Analyzing Qualitative Data, Program Development and Evaluation. *University of Wisconsin-Extension Cooperative Extension, Madison, Wisconsin.*

Teece, D. J. (2007). Explicating dynamic capabilities: the nature and micro foundations of (sustainable) enterprise performance. *Strategic management journal, 28*(13), 1319-1350.

Teja, A. (2017). Indonesian FinTech business: New innovations or foster and collaborate in business ecosystems? *The Asian Journal of Technology Management, 10*(1), 10-18.

Thomas, W. (2014). Modelling and Qualitative Scenarios. PowerPoint Presentation of OECD – NAEC Seminar. Retrieved from https://www.slideshare.net/OECD_NAEC/oecd-presentation-shell-thomas-1-dec14-v1.

Tudzarov, A., & Gelev, S. (2017). Requirements for next generation business transformation and their implementation in 5G architecture. *International Journal of Computer Applications, 162*(2), 31-35.

Vora, L. J. (2015). Evolution of mobile generation technology: 1G to 5G and review of upcoming wireless technology 5G. *International journal of modern trends in engineering and research, 2*(10), 281-290.

Wood, S. C., & Brown, G. S. (1998). Commercializing nascent technology: The case of laser diodes at Sony. *Journal of Product Innovation Management 15*(2), 167-183.

Yole Development. (2017, Oct 12th). 5G's impact on RF front-end industry: How will wireless infrastructure and cell phone terminals change in the next decade. Retrieved from https://www.slideshare.net/Yole_Developpement/5gs-impact-on-rf-frontend-industry-how-will-wireless-infrastructure-and-cell-phone-terminals-change-in-the-next-decade-2017-report-by-yole-developpement

Zadeh, N. K., Khalilzadeh, M., Mozafari, M., Vasei, M., & Ojaki, A. A. (2017). Challenges and difficulties of technology commercialization− a mixed-methods study of an industrial development organization. *Management Research Review 40*(7), 745-767.

Zahra, S. A., & Nielsen, A. P. (2002). Sources of capabilities, integration and technology commercialization. *Strategic Management Journal, 23*(5), 377-398.