Analysis on Competition Type between Fixed and Mobile Broadband Services in Indonesia

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A B S T R A C T

Both fixed and mobile broadband technologies are adopted in Indonesia. This study aims to identify the competition model between both of them. The non-linear exponential model is employed to estimate the diffusion pattern of both broadband services. Meanwhile, the Lotka-Volterra method is applied to identify the competition model between those two. Results of the study show that for the Indonesian telecommunication market, competition between fixed and mobile broadband is a mutualism or a win-win solution. This allows the deployment of both fixed and mobile broadband even in the same region without worrying that mobile broadband technology will hinder fixed broadband and vice versa. Considering the topography of the regions of Indonesia, especially those categorized as rural areas, the existence of both fixed and mobile broadband technologies is crucial to accelerate the distribution of equal access to broadband internet for all Indonesian people, both in urban and rural areas. This condition becomes more urgent when commercial 5G services is deployed in Indonesia.

1. Introduction

At present, ICT (Information and Communication Technology) has been an integrated part of our lives. For most of our routine activities, we are demanded to interact with ICT things such as smartphones, laptops, and the internet. ICT comprises both hardware and software that form networks and act as a media for collecting, processing, transmitting, and presenting information in the form of voice, text, data, or images (World Bank, 2003). The development of ICT enables people to communicate quickly and easily. In the era of technological convergence, ICT can be perceived as a collaboration between information technology, telecommunication, and broadcasting fields. In the ICT world, there are two types of communication services people are familiar with, circuit-switched services and packet-switched services. Telephony, facsimile, and short message service (SMS) are examples of circuit-switched services. Meanwhile, internet-based services like mobile banking, Voice over Internet Protocol (VoIP), and teleconference are some examples of packet-switched services. Before the era of broadband technology, circuit-switched services were more massively used among people than packet-switched ones. The introduction of broadband technology has changed this trend. Ever since, the use of packet-switched service has been growing significantly and surpassing that of circuit-switched service (Ericsson, 2019). Slowly but surely, the internet-based services, which is packet-switched service, has been dominating over circuit-switched service. The existence of broadband technology also ignites the rise of various internet-based applications such as virtual reality, e-commerce, online gaming, news streaming, and the internet of things (IoT), to name a few. The diverse internet-based applications have transformed the way people communicate with each other. Aside from that, it also acts as help to increase the productivity of either individual or organization. For example, e-commerce helps people, especially households, start their online businesses; thus, they could get additional incomes. In addition, the use of e-commerce helps both new and existing sellers expand targeted markets for their products. Another example is that the use of IoT can help manufacturing industries to achieve more efficient business processes. Increased productivity of both individuals and organizations increases economic growth. International Telecommunications Union (ITU) has stated that a 10% increase in broadband penetration will lead to an increase in the Growth of Domestic Product (GDP), spanning from 0.25% to 1.38% (ITU, 2012).

Indonesia is a country consisting of many islands and surrounded by seas; thus, accelerating equal economic development throughout Indonesia is quite challenging for the government to achieve. Therefore, broadband technology is a solution to cope with that. In the Master Plan Indonesian Economic Development 2011-2025, also known as Masterplan Percepatan dan Perluasan Pembangunan Ekonomi Indonesia 2011-2025 (MP3EI), one of the main strategies to realize that is by strengthening connectivity at the national level. In the context of MP3EI, connectivity is not limited to transportation infrastructure that facilitates the movement of people, goods, and means of transportation but also the exchange of information. Information and Communication Technology (ICT), specifically broadband technology, are essential components to achieve firm national connectivity (Bappenas, 2011). The Indonesian government expects US$ 4-4.5 trillion of GDP in 2025, and the use of broadband technology is essential to achieve that target (Bappenas, 2014). Considering that economic development is not merely about increasing GDP, thus the use of broadband technology to accelerate economic development aims to boost the economic sector and others such as education and health.

There are two categories of broadband technology, mobile broadband, and fixed broadband. Both of them are implemented in Indonesia. Even though these two are used in Indonesia, the development of fixed broadband service is not as fast as that of mobile broadband service. Data from the ITU on ICT Country Statistics show that at the end of 2017, the number of mobile broadband subscriptions in Indonesia reached 435 million people. In comparison, the number of fixed-broadband subscriptions is only 1.4% of mobile broadband subscriptions (ITU-D, 2021). From this, it can be seen that there is a large gap between mobile broadband and fixed broadband subscription. This gap raises an inquiry into how mobile broadband and fixed broadband services interact in the scope of the Indonesian telecommunication market. This article investigates the competitive relationship between mobile broadband and fixed broadband subscription in Indonesia. Identifying the competition model between those two will give the government insight into choosing a suitable strategy in accelerating broadband penetration in Indonesia in need of underpinning economic development. For example, if the competition model between those two is a substitution, the government can choose which one of them should be deployed suitably in a particular region. In another case in which these two broadband technologies are pure competition, the government needs to consider another strategy to implement these two. Considering that the competition model between fixed and mobile broadband could differ from one country to another, the result of this study would also provide additional insight to existing studies, specifically a description regarding the characteristic of interaction between fixed and mobile diffusion for the Indonesia telecommunication market.

2. Literature Review

There are several definitions of broadband. ITU states that an internet connection with a minimum speed of 1.5 Mbps (Megabit per second) or 2 Mbps is categorized as broadband (International Telecommunication Union, 1997). In this study, the author adopts the broadband definition according to Indonesia National Broadband Plan. Under the National Broadband Plan of Indonesia 2014-2019, communication technology is categorized as broadband technology if it can provide an internet connection with a minimum data rate of 2 Mbps for fixed broadband and 1 Mbps for mobile broadband. This technology should support triple-play services (audio, video, and data), always-connected, reliable, and secure internet connection (Bappenas, 2014). *Mobile broadband* is a high-speed internet connection that can support triple-play services through mobile devices (Srinuan et al., 2011). Unlike mobile broadband, fixed broadband can only support internet connection with relatively fixed positioned devices. Those broadband technologies come with superiorities and drawbacks regarding flexibility, performance, and deployment. Mobile broadband has some features that allow users to move around a large scale area and still get connected to the internet as long as their mobile devices are under the coverage area of the BTS (Base Transceiver Station) of mobile network providers. Furthermore, fully wireless mode communication between mobile networks and end-user devices makes the deployment of a mobile broadband network is faster than fixed broadband. The cost of deployment is also lower than that of fixed broadband. Nonetheless, communication through a mobile broadband network is more prone to power attenuation and interference when signal communication traverses between user devices and mobile networks.

This will degrade the data transfer speed and power level of the signal communication. The possibility of power attenuation and interference in fixed broadband network is slighter than those of mobile broadband because almost all communication between sender and receiver are delivered through guided media (optical fiber cable) while only a small part of it is delivered using wireless communication in case of fixed wireless broadband (example; WiFi connection between an access point and end-user devices). This condition makes the performance (transfer speed and power level) of fixed broadband is better than that of mobile broadband. The installation of optical fiber cable will need the availability of the ducting facility to assure that bundles of many optical fiber cables can be placed in a safe container. This requirement makes the deployment of fixed broadband networks longer, and the investment costs get higher than that of mobile broadband. Considering the excellence and downside inherited from each of them, the combination of mobile and fixed broadband would be an excellent solution to accelerate equal access to an internet connection for all Indonesian people. However, to what extent the Indonesian government should combine fixed and mobile broadband to achieve it, one needs to know the type of competition between those two.

Several authors have conducted studies that discuss either mobile broadband or fixed broadband in some context. Research conducted by (Gupta & Parida, 2013) discusses the challenges and opportunities of mobile broadband. It is said that mobile broadband is getting more attractive to users than fixed broadband, and significant growth of mobile broadband traffic so far has proven it. However, as mobile broadband traffic grows, end-to-end Quality of Service (QoS) needs to be maintained. This becomes a challenge for mobile network providers because the higher the traffic volume, the higher the chance of capacity bottleneck and interference among mobile users. In the end, this will degrade the QoS of mobile broadband. In terms of the number of subscriptions, fixed broadband is still left behind mobile broadband (Nandi & Subramaniam, 2011). The current fact that users prefer using mobile broadband rather than fixed broadband might change when 5G comes to commercial deployment. This is due to convergence between mobile and fixed broadband being required to unleash the full potential broadband services for all (Broadband Forum, 2018; Huawei, 2019). Super fast and ultra-low latency communication offered by 5G technology demands the mmWave (millimeter wave) frequency spectrum that provides super capacity. However, the use of mmWave frequency brings with it a consequence which is signal communication using this mmWave frequency is only able to traverse in a very short distance, around 500 meters at frequency 28 GHz, before it has to be attenuated by the repeater (Samsung Electronics, 2015). The distance, however, will get shorter as the frequency gets higher than 28 GHz. Therefore, optical fiber cable, which is crucial for fixed broadband service, is required to overcome that distance limitation. This optical fiber cable works as a backbone and backhaul for signal transmission; thus, the signal communication can reach a longer distance on its way from mobile devices to the 5G network and vice versa.

Besides the articles mentioned earlier on mobile and fixed broadband, several studies compare those two. One of them is a study conducted by Carol in which it is found that several factors are contributing to whether consumers choose mobile or fixed broadband. Those factors include throughput and connection stability of those two, service prices, availability of each broadband technology in consumer's living area, the structure of network operators that provide those two, and the marketing strategy adopted by network providers (Carol, 2012). The contribution of these factors to users' preferences in choosing broadband service could differ between one country and another. Thompson and Garbacz investigate the effect of mobile and fixed broadband on GDP (Thompson and Garbacz, 2011). The study results are that mobile broadband directly impacts country GDP, especially in low-income countries. Meanwhile, the contribution of fixed broadband to GDP is only slightly higher than zero. (Grzybowski, 2014) investigates about substitution pattern between fixed and mobile access services in the European Union. His study reveals that the larger the spread of mobile access services, the more people will switch from fixed to mobile access services. Despite that, the speed of fixed-to-mobile substitution may decelerate if network operators can provide a bundled package of fixed along with mobile services to customers. Another study (Srinuan et al., 2012) identified a competition model between mobile and fixed broadband in Sweden. Study results show that fixed broadband services can be substituted by mobile broadband ones in almost all areas in Sweden based on the own-price and cross-price between those two broadband services. Lin also conduct a study to identify competition model between 4G WiMAX and 3G

mobile broadband in Taiwan, and the result of his study shows that competition between those two in Taiwan is commensalism, meaning the existence of 3G mobile broadband is not a replacement for the 4G WiMAX (Lin, 2013).

3. Method

3.1. Competition relationship of mobile and fixed broadband

For this study, the author uses open access data on Indonesia's mobile and fixed broadband subscription from ITU-D on ICT Country Statistics (ITU-D, 2021). The quantitative method is applied to analyze the data and results with the competition between mobile and fixed broadband services in Indonesia.
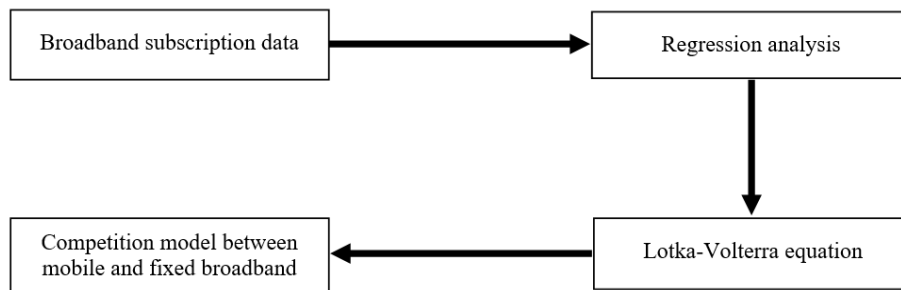

Figure 1. Flow of data analysis

Each mobile broadband and fixed broadband subscriber data is analyzed using non-linear exponential regression to calculate the estimated parameters or coefficients of that non-linear model. The parameters are then fed to the Lotka-Volterra equation and present the competition coefficient values for each of those two broadband services. Based on those competition coefficients, it would be possible to identify the competition model between mobile and fixed broadband.

3.2. Lotka-Volterra model

Before the data is fed to Lotka-Volterra, they are analyzed using a non-linear exponential regression model as shown in equation 1 with two parameters, α, and β (Hathout, 2013).

$$P\ (t) = \alpha e^{\beta t} \quad \text{...1)}$$

P (t) represents the percentage of the broadband subscriber at year *t*. The year 2010 is translated as t = 1, continuing until t = 11 (meaning that year 2020). This rule also applies to equation 2 until 3. *α* is the broadband subscriber's peak or saturation point in the form of a percentage, β is the growth rate of the broadband subscriber, and *e* is the Euler number which has a constant value of 2,71828. The ITU data is fed onto regression analysis using an exponential model based on equation 1 through Minitab software. The regression analysis done using Minitab comes up with the estimated value of *α* and β for each fixed and mobile broadband. Meanwhile, finding the competition coefficient for each of those two is done using the Lotka-Volterra model. The Lotka-Volterra is one of the widespread methods used to analyze how two species compete (Lee Seong-Joon et al., 2005). In this study, these two species are mobile broadband and fixed broadband services. Stages in calculating competition coefficient are carried on using several equations, from equation 2 until 6, refers to one provided by (Lee Seong-Joon et al., 2005). In equations 2 and 3, *x*(t) and *y*(t) are the percentages of fixed and mobile broadband subscribers respectively at year *t,* while n is the latest year or upper limit year in which the data is observed. In this study, the data's duration was observed is 11 years. Thus, the value for n is 11, representing the year 2020.

$$x(t+1) = \frac{\alpha_1 x(t)}{1 + \beta_1 x(t) + \gamma_1 y(t)}, t = 1, 2, ..., n-1 \quad \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots \text{2)}$$

$$y(t+1) = \frac{\alpha_2 y(t)}{1 + \beta_2 y(t) + \gamma_2 x(t)}, t = 1, 2, ..., n-1 \quad \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots \text{3)}$$

$$a_i = \ln \alpha_i \quad \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots \text{4)}$$

$$b_i = \frac{\beta_i a_i}{\alpha_i - 1} = \frac{\beta_i \ln \alpha_i}{\alpha_i - 1} \quad \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots \text{5)}$$

$$c_i = \gamma_i \frac{b_i}{\beta_i} = \frac{\gamma_i \beta_i \ln \alpha_i}{\beta_i \alpha_i - 1} = \frac{\gamma_i \ln \alpha_i}{\alpha_i - 1} \quad \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots \text{6)}$$

The value of Υ_i for each species is acquired through Equation 2 and 3 using the value of α and β. The value of Υ_i specifies to what extent the rate of increase of one species impacts the other species. Υ_1 is aimed to represent that of fixed broadband, while Υ_2 indicated that of mobile broadband. The values Υ_1, Υ_2, α_1, α_2, β_1, and β_2 are then employed in equation 4 to 6 to calculate parameters a_i, b_i, and c_i. Parameter a_i and b_i are the Lotka-Volterra coefficient when each species lives without any competitor co-exist, while c_i is the competition coefficient of one species to the other species.

Table 1. Competition relationship based on the signs of competition parameters c_1 and c_2

c_1	c_2	Competition Type	Explanation
-	-	Pure competition	Occurs when both species are negatively impacted from each other's existence
+	-	Predator-prey	Occurs when one of them serves as direct food to the other
+	+	Mutualism	Occurs when each other's existence benefits both species or a win-win situation
+	0	Commensalism	Occurs in a parasitic type of relationship in which one benefits from the existence of the other, who nevertheless remains unaffected
-	0	Amensalism	One suffers from the existence of the other, who is impervious to what is happening
0	0	Neutralism	Occurs if there is no interaction whatsoever

Source: (Lin, 2013)

The competition model between two species is decided based on thes sign of competition coefficient c_i, as depicted in table 1. In other words, based on the signs of c_1 and c_2, one will identify the way these two species compete with each other. In this study, c_1 and c_2 are competition coefficients for fixed and mobile broadband, respectively.

4. Result and Discussion

Figure 2 represent the number of mobile and fixed broadband subscriber in Indonesia. They are sourced from network operators in Indonesia to the Ministry of Communication and Informatics of Indonesia. Based on the information provided in the ITU data, some mobile network operators do not yet provide the whole and final data of their mobile subscribers for year 2016, 2018, and 2019. This uncompleted data certainly makes the number of mobile broadband for those years show a decreasing pattern rather than increasing one.

The broadband data are analyzed using non-linear exponential regression and results with the estimated value of the exponential parameters α and β along with MSE (Mean Squared Error) and standard error S, as presented in table 2. Parameters α and β for both fixed and mobile broadband are then employed to get the

value for Lotka-Volterra competition coefficient using equations (2) to (6). Values for parameters a, b, ϒ, and competition coefficient *c* for both broadband technologies can be seen in table 3.
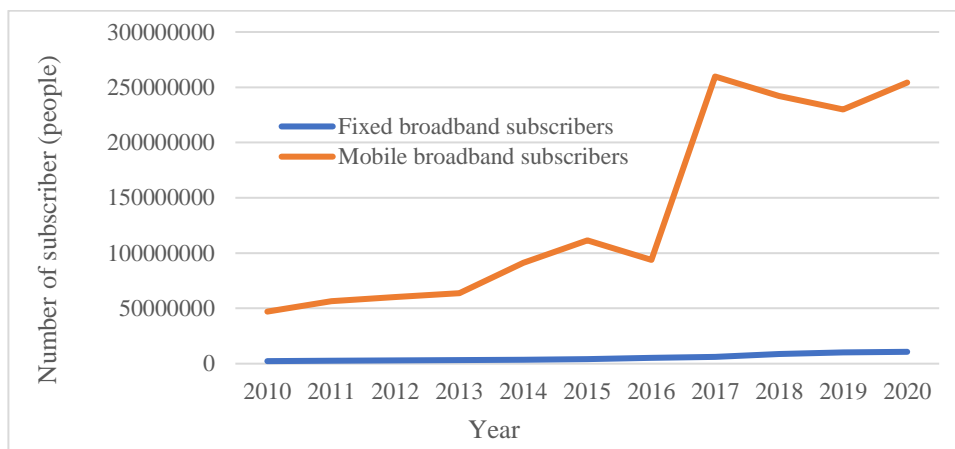

Figure 2. Indonesia Broadband Subscribers (ITU-D, 2021)

Table 2. Exponential model parameters estimation

Parameters	Fixed Broadband Subscription	Mobile Broadband Subscription
α	0,006675	0,164401
β	0,166035	0,165022
MSE	0,0000054	0,022
S	0,0023	0,148

Table 3. The value of parameters *a*, *b*, ϒ, and *c* for fixed and mobile broadband

Parameters	Fixed Broadband Subscription	Mobile Broadband Subscription
a	-5,0093861	-1,8054467
b	-125,60426	-2,8122665
ϒ	0,19	0,22
c	3961,574,235	1515,6462

Based on the result of the Lotka-Volterra equation, both fixed broadband and mobile broadband have a positive sign for their competition coefficient c_1 and c_2, respectively. By the rules of competition coefficient in table 1, it is seen that both fixed broadband and mobile broadband benefit from each other's existence or mutual relationship. Instead of suffering from each other's presence, both fixed and mobile broadband services in Indonesia are in a state of a win-win situation. This means that each of them acts as a complement for the other. In a region where mobile broadband is not available yet or poor signal quality of mobile broadband, people prefer to subscribe to fixed broadband services and vice versa. Although fixed and mobile broadband services in Indonesia are mutual competition, one interesting fact is found when observing subscription data for fixed and mobile broadband in figure 2. The data tells us that the growth of mobile broadband subscriptions is more significant than that of fixed broadband during 2010-2020. An explanation for this is that in the case of Indonesia, some internal factors contribute to the slow growth of fixed broadband subscriptions. In this context, internal factor means that it comes from fixed broadband service itself, which are the availability of optical fiber cable infrastructure and the topography of Indonesia.
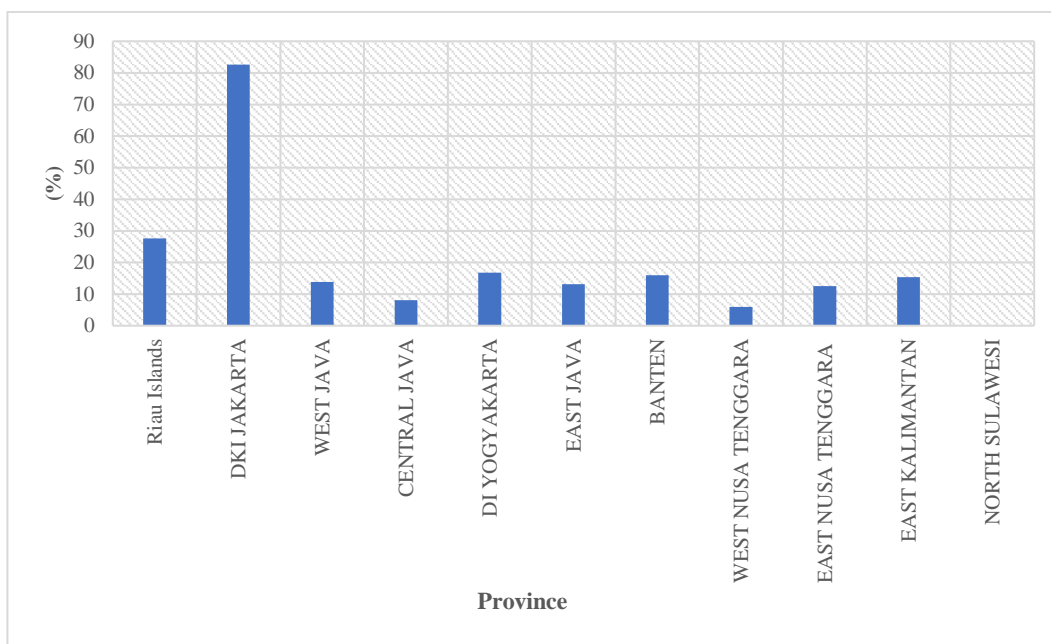
Figure 3. The percentage of Indonesia households having access to fixed broadband service (katadata, 2019)

Figure 3 presents data on the percentage of households in Indonesia that have access to fixed broadband service in 2019. It can be seen that only the capital city of Indonesia, Jakarta that is already covered with more than 80% fixed broadband network. Considering that fixed broadband is closely related to the optical fiber network, the data presented in figure 3 can also be used as an indicator to what extent the optical fiber network has covered a specific area. Based on that, we may conclude that only Jakarta, the coverage of the optical fiber network, has reached more than 80% of its area. In terms of topography, many rural areas in Indonesia are surrounded by hills, mountains, and heavy vegetation, while others are located on islands separated from the mainland. This situation is challenging for deploying optical fiber networks on a massive scale. Those factors that led to the growth of fixed broadband are not able yet to catch up with mobile broadband from 2010 until the present. This fact matches with the result of the Lotka-Volterra analysis that in the case of the Indonesian telecommunication market, the competition model between fixed and mobile broadband is mutualism. Instead of it being led by mobile broadband, the pressure on the growth of fixed broadband subscriptions is caused by internal constraints in the deployment of fixed broadband itself.

5. Conlusion

This article investigates the competition model between fixed and mobile broadband for the Indonesian telecommunication market. Applying non-linear exponential regression and the Lotka-Volterra model to analyze the raw data, the competition between fixed and mobile broadband services is mutual for the Indonesian telecommunication market. This result is supported by the fact that the slow growth of fixed broadband service in Indonesia results from internal constraints in the deployment of fixed broadband itself rather than the fast adoption of mobile broadband service. Based on this study findings, it concludes that the government can deploy both fixed and mobile broadband in the same region. This is because both broadband technologies benefit from each other's existence rather than one broadband service preventing the other from growing. This certainly fits the condition in Indonesia with diverse topography, especially those categorized as rural areas, thus requiring a combination of fixed and mobile broadband services to accelerate the distribution of equal access to broadband internet for all Indonesian people. It becomes more urgent when commercial 5G services come to Indonesia, which demands the convergence between both broadband technologies to release the full potential of 5G services both in urban and rural areas. Considering the limitation of this study, further research on each fixed and mobile broadband will be required, mainly investigating more detail on several factors that contributes to the adoption pattern of fixed and mobile broadband technology in Indonesia. Considering

additional factors such as price and regulation, market characteristics, and so forth could be included in the subsequent studies.

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