Competition and Mobile Network Operator's Investment Relationship: A Firm Level Empirical Evidence for Developing Countries

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Abstract: Policymakers have reformed the telecommunications market structure for several decades, from a monopoly to a more competitive market. They believed that the competitive market structure would be able to overcome the limitations of investment required to develop the industry and to provide equitable access. However, the advance of mobile broadband technology has triggered the emergence and proliferation of over-the-top (OTT) services that have considerably changed the competition landscape. First, in addition to acting as new competitors, the availability of OTT services also helps Mobile Network Operators (MNOs) to acquire more subscribers. Second, the competition has broadened to cross geographical boundaries. This paper aims to investigate the effect of the competition intensity on MNOs' investment behaviour in the most recent context and focus only on MNOs in developing countries. The results show that competition intensity and MNO's investment behaviour have an inverted U-shaped relationship with a turning point of 0.61. This points to the existence of competition intensity that maximizes the MNO's investment. The empirical results also show the cumulative impact of the competition intensity on investment is 12.5 times of the immediate impact.

Keywords: Competition intensity, Investment, Mobile Network Operator, Digital age

Introduction

The reform of the telecommunications market structure, from a monopoly to a pro-competitive market structure, began almost four decades ago. This reform was based on the premise that competition can encourage investment and innovation (Lestage *et al.*, 2013).

However, the introduction and the fast advancement of mobile broadband technology has triggered the emergence and proliferation of over-the-top (OTT) services that considerably

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changed the competition landscape in several ways. First, OTT service providers act as new competitors for MNOs, since they offer substitutions for conventional voice and message services. In this case, the OTT service providers have the same effect as existing competitors (other MNOs), i.e., threaten an MNO's revenue. However, OTT service providers are different in that they also provide advantages for MNOs by enriching existing services offered to the MNO's consumers. This helps MNOs to acquire new consumers as well as to encourage existing consumers to consume more bandwidth, which means more revenue for MNOs (Bilbil, 2018; Sujata *et al.*, 2015). Second, the broadband technology also has broadened the competition field, fading geographical boundaries. OTT service providers can serve their consumers from any location in the world and harm MNOs' profitability. Their services present to the MNO's consumers as soon as the MNO launches its own broadband services.

At the same time, MNOs are encouraged to sustainably improve their network performance. As predicted by Cisco, there will be a threefold IP-based traffic increase in the period 2017 to 2022 and is expected to keep increasing (Cisco, 2018), requiring higher network capacity. In addition, future applications such as smart grids, intelligent transportation, disaster emergency, tele-health, industry 4.0-based production systems, etc., require higher reliability as well as higher security levels of the networks. The networks are also required to be able to serve not only humans but also a large number of objects, which will amount to around 25 billion by 2025 (GSMA, 2018). To meet those requirements, MNOs are required to innovate and invest sustainably.

The change in the competitive landscape, as well as the increase of the demand for investment, must be taken seriously. The failure to define proper competition policy could lead to the inability to encourage MNOs to invest in their networks continuously. Further, it will cause failure in providing required network performance. As the role of the communication network is increasingly substantial in the digital age (GSMA, 2016; WEForum, 2017), it is difficult to grasp any opportunity offered at this age.

Unfortunately, there are different theoretical views on the competition and investment relationship. A sceptical view from Schumpeter (1942) states that there are many situations where a concentrated market structure is an optimal market structure. The first reason is the economic scale of the market causes the market to consist of only a few companies. The second and most important reason is the desire of companies to occupy a monopoly position in the future, so that encourages them to invest or innovate today (Schumpeter, 1942). In other words, because a monopolist is a price maker, they have large enough financial reserves and financial adequacy to keep investing. On the contrary, Arrow (1962) has conveyed the opposite view. According to him, a company in a competitive market has a greater tendency to innovate than a monopolist. This phenomenon is called an escape-competition effect. This effect is

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related to the profits obtained by a company in the competitive market when the company becomes a pioneer in new technology (Arrow, 1962). We can also view the Arrow effect as a replacement effect, namely a low incentive for monopoly companies to replace old technology with new ones because of the profitability of current technology (Tirole, 1988). Similarly, previous works also found diverse findings. Some of them focused on the fixed network broadband market. A study by Grajek and Röller (2009) found that competition caused by regulations requiring incumbent companies to share access with new entrants had a negative impact on investment. Bacache, Bourreau, and Gaudin (2014) concluded that access regulation did not have a significant impact on the investment of new entrants to the fixed broadband market. Meanwhile, in the mobile telecommunications industry, most of them focus on competition and investment relationships in developed countries (Elixmann *et al.*, 2015; Garrone & Zaccagnino, 2015; Jeanjean & Houngbonon, 2017; Lestage *et al.*, 2013). Although there are several studies on developing countries, such as those conducted by Kang *et al.* (2012) and Mutinda (2016), they focused on the industry level. The study on the industry level is only appropriate if the objective of competition policy is the industry performance in general. However, in this case, it will be difficult to define a more detailed strategy to increase or decrease competition intensity. For example, if a policymaker intends to decrease the competition intensity through company consolidation, the policymaker does not have enough information on which companies should be encouraged to consolidate. Another study by Houngbonon & Jeanjean (2016) has scrutinized the competition-investment relationship on the firm level for developed as well as developing countries. However, their findings only reflect the relationship for MNOs with positive earnings before interest, tax, depreciation, amortization (EBITDA) margin. Therefore, the present study tries to fill the gaps by analyzing the firm-level data and including not only MNOs with positive EBITDA margin but also those with negative EBITDA margin. In addition, this study only focuses on developing countries as these countries rely more on mobile networks than developed countries (ITU, 2017).

Method

Data

The data consists of the following: i.) total capital expenditure, Ebitda margin, and cashflow of MNOs obtained from the Thomson Reuters database; ii) GDP per capita and population figures from the World Bank; iii) the penetration rate of fixed broadband services from the International Telecommunication Union (ITU); and iv) check and balance and stability as proxy of political institutions obtained from the Inter-American Development Bank (IADB). Some data is only available annually, so that the quarterly period in the same year is averaged, under the assumption that it is constant throughout the year. Financial report data is at the

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company level, while other data is at the country level, so that companies residing in the same country will have the same value.

Sample

The sample consists of MNOs operating in developing countries, with the exclusion of virtual operators (MVNOs). Twenty-three MNOs from the following developing countries were selected: 1 from India; 3 from Thailand, 1 from Mexico, 3 from Malaysia, 2 from Egypt, 2 from Philippines, 4 from Indonesia, 1 from Bangladesh, 2 from Turkey, 1 from Kazakhstan, 1 from Sri Lanka, 1 from Russia and 1 from Sudan. The data form panel data with a maximum time span starting from quarter 1 in 2009 to quarter 4 in 2017.

Empirical model

The empirical model illustrates the relationship between MNO's investment and the intensity of competition experienced by the MNO. The basic model in this study is presented in equation (1). The hypothesis is that there is coexistence between the Schumpeter effect and the Arrow effect, which causes a nonlinear relationship between competition and investment. This relationship can be in the form of an inverted U curve as shown by Aghion *et al.* (2005) or U-shaped as shown by Sacco & Schmutzler (2011).

$$I_{it} = \mathrm{f}(I_{i(t-1)}, \Phi_{it}, \Phi_{it}^2) \tag{1}$$

I_{it} is the dependent variable, i.e. investment of operator i in period t. It is measured by the accumulated expenditures of fixed assets and expenditure on intangible assets of operator i in quarter t. $I_{i(t-1)}$ is operator investment i in the previous period $(t-1)$. The reason for the inclusion of $I_{i(t-1)}$ in the model is because: (1) adjustments to capital expenditure occur slowly in response to changes in other factors; (2) MNOs are likely to have a long-term investment plan: therefore there is a possibility of investment dependence between periods (Frontier, 2015). Another reason for using this lagged dependent variable is the possibility of the gradual impact of an independent variable on the dependent variable (Lestage *et al.*, 2013). It is possible to include a larger lag. However, several similar studies confirm that investment does not depend on a larger lag (Alesina *et al.*, 2005). Φ and Φ^2 are competition and square of competition variables. The level of competition is measured based on the Lerner index. According to Aghion *et al.* (2005), the Lerner index is better at measuring the level of competition compared to the market share or Herfindahl-Hirschman Index (HHI) because both are very dependent on the accuracy of geographical and product definitions that are very difficult to do, especially in the digital age where data and information flows are no longer limited by geographical boundaries. This makes market concentration that is only measured by data in one region or country susceptible to bias. The Lerner index of a company is the ratio of the gap of product price (P) and marginal cost (MC) to the price of the product (P) (Pindyck & Rubinfeld, 2013). Companies with higher competitiveness have better ability to minimize costs (C) and to determine the selling price (P) of their products so that they can maximize revenue. Because the Lerner index is calculated based on corporate financial data, it is more flexible to use since every change in the competition intensity, whoever causes the change (including by the emergence of the OTT), will be reflected in the corporate financials. Theoretically, the Lerner index, denoted by L, ranges from 0 to 1. If L is equal to 0, the company is operating in a perfectly competitive market where P = MC. L value of 1 indicates that the company has a high market power. P and MC are difficult to obtain. Therefore, service prices (P) are replaced by revenue, while marginal cost (MC) is replaced by total operational cost. Revenue is an accumulation of the selling of voice, data, roaming, international calls, and interconnection services. The difference between revenue and marginal cost is called Earnings before interest, tax, depreciation and amortization (EBITDA). Therefore, the intensity of competition can be calculated by equation (2).

$$\Phi_{it} = 1 - \frac{ebitda_{it}}{revenue_{it}} = 1 - EBITDA\,margin \qquad (2)$$

Estimation strategy

The use of lagged investment variables as one of the explanatory variables in the panel data structure is a characteristic of dynamic panel data. The best way to overcome the bias in a dynamic panel is to use least square dummy variable (LSDV) estimation (Kiviet, 1995). However, we cannot apply this approach to an unbalanced data panel. Besides, LSDV cannot overcome the problem of endogeneity (Roodman, 2009). A variable is said to be endogenous if the value of the variable is determined in the context of an econometric model. Endogeneity also describes a condition in which one or several variables have a relationship with the error term (Wooldridge, 2002). This study uses a dynamic panel model with unbalanced data panels and there is a possibility of simultaneity bias of competition and lagged investments to the contemporaneous investment, so that LSDV estimation is not appropriate to be applied in this study.

According to Wooldridge (2002), there are three causes of endogeneity, namely: 1) omitted variable bias; 2) measurement error; and 3) the possibility of a two-way relationship between independent variables and the dependent variable (simultaneity). The existence of these biases in the model causes inconsistency of estimation results and inaccuracy of conclusions. This study takes several anticipatory steps to minimize these biases as follows.

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1) omitted variables bias

We mitigate this bias by including several control variables into the basic econometric model. The addition of control variables into the base model can also be useful as a robustness check (Lu & White, 2014). Equation 3 is the complete model after the inclusion of control variables.

$$I_{it} = \beta_0 + \beta_1 \Phi_{it} + \beta_2 \Phi_{it}^2 + \gamma I_{i(t-1)} + \sum_{n=1}^{N} \vartheta_n X_{nit} + \varepsilon_{it} \tag{3}$$

$\beta_0, \beta_1, \beta_2, \gamma$ and ϑ_n are the parameters to be estimated, and ε_{it} is a random error with zero mean and constant variance that satisfies the classical assumptions of homoskedasticity and the absence of serial correlation. X is a vector of control variables; n points to the nth control variable. N is the number of control variables. The control variables in this study consisted of operator cash flow in the previous period, the number of the population, gross domestic product (GDP) per capita, political institutions, and time effects. Positive cash flow is one of the company's financing sources that can be used to finance investment projects, especially in the case of capital market imperfections and asymmetric information (Garrone & Zaccagnino, 2015). Although in fact some or all investment projects are debt-funded, high cash flows illustrate the company's ability to pay the debt instalments. The population and GDP per capita illustrate the market size and market demand. Logically, large markets offer higher profit opportunities that encourage companies to innovate and to invest so that they can attract more potential customers. According to Dixit & Pindyck (1994), uncertainty is one of the characteristics of an investment project, and poor political institutions are one of the causes of uncertainty. Poor political institutions will discourage companies to invest, as the government may arbitrarily change current policies and cause losses to the investor (Stasavage, 2002). This explains the importance of good political institutions, which are characterized by the existence of checks and balances in fostering a conducive climate for investment (North & Weingast, 1989). This study also includes political stability variables that illustrate the change in power in a political system. The time effect serves to capture the possibility of investment trends in addition to capturing the effects of the adoption of new technology. Dummy variables for quarter and year are used to capture the time effects. Each dummy variable has value of 1 in the corresponding quarter or year and 0 for the others. To avoid collinearity, we do not include the first quarter and the first year in the model and treat them as reference variables.

2) measurement error

A measurement error problem occurs when an independent variable is clearly defined, but the data used as a measure of the variable contains errors (Wooldridge, 2002). In this study it is

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very difficult to avoid measurement errors considering the use of secondary data. It is difficult to obtain access to primary data to validate the data.

3) simultaneity

In practice, researchers often overcome simultaneity by replacing an endogenous variable with its lagged variable. This will, however, not be able to eliminate the bias. Alternatively, lagged endogenous variables are used as instrument variables in two-stage least square estimate (2SLS), in generalized method of moments (GMM) estimate, or in limited information maximum likelihood (LIML) estimate (Reed, 2015). According to Hansen, 2SLS has a weakness compared to GMM especially when heteroscedasticity and autocorrelation problems exist (Hansen, Heaton & Yaron, 1996). Likewise, LIML requires homoscedasticity (Baum, Schaffer & Stillman, 2003). Therefore, the Generalized Method of Moments (GMM) is considered as the most suitable approach for this study. In addition to its ability to handle dynamic panel data, GMM also has the ability to overcome endogenous problems by using lagged variables as instrument variables (Cameron & Trivedi, 2005). A good instrument variable is able to meet the requirements of validity and strength. An instrument is valid if it does not have a correlation with errors, while its strength is measured by how strong the relationship is with its endogenous variable. To avoid the possibility of correlation between the first lagged variable (*t-1*) with errors, this study uses the second lagged variable (*t-2*) as the instrument variable of each endogenous variable.

Results and Discussions

Descriptive statistics

Table 1 shows descriptive statistics of the variables used in the estimation. Investment ranges from 0.014 billion USD to 4.7 billion USD. The range is quite large and usually relates to a company's market size. As discussed in the methodology, this study uses EBITDA margin as a measure of the Lerner index (L). Theoretically, the Lerner index ranges between 0 and 1. However, as presented in Table 1, 1-Lerner has a maximum value of 1.967 which means there are Lerner indexes, represented by EBITDA margin, that are less than 0. This is an indication that the company's total income is unable to cover the company's operating costs.

Table 1. Descriptive statistics

Variables	Observations	Means	Std Dev	Min	Max
Investment (billion USD)	814	284.225	504.191	0.014	4,746.9
(1-Lerner)	814	0.635	0.178	0.004	1.967
$(1\text{-Lerner})^2$	814	0.435	0.331	0.000	3.869
Cashflow (million USD)	814	0.004	0.593	-6.620	6.769
Population (million)	814	159	253	16.800	1,340

Variables	Observations	Means	Std Dev	Min	Max
GDP per capita (USD)	814	5,783.14	3883.88	726	14,936
Stability	814	0.118	0.237	0	1
Check and balance	814	3.091	1.451	1	17
Fixed broadband subscribers (million)	814	5,288	5,448	0	31,100
Quarter	814			Q1 2009	Q4 2017

Source: Thomson Reuters (2019), ITU-D (2019), IADB (Scartascini, Cruz & Keefer, 2018), and World Bank (2019b, 2019a)

Estimation results

In the estimation process, several variables are converted to logarithmic values. This aims to reduce the bias caused by heteroscedasticity. To avoid error and negative values, logarithmic operation is only applied to variables having values that are positive, continuous, and more than 1. Therefore, cash flow, 1-Lerner, and dummy variables are excluded from the conversion. This study uses GMM estimation method with instrument variables (IV GMM) to confirm the causal relationship between the intensity of competition and the investment behaviour of MNOs. This study only uses internal instrument variables, namely the two-period lagged variables (t-2) of $I_{(t-1)}$, Φ_t and Φ_t^2. According to Reed (2015), internal instruments are capable of providing consistent and valid estimation results.

We carry out a robustness check to test the estimation consistency by modifying the basic model specification by adding one or several independent variables (Lu & White, 2014). In this study, the robustness check is done by developing 6 model specifications. Model specification 1 is the basic model, which only consists of the main variables, while model specification 6 is the most complex model. The results of each model specification are then compared with each other to see the consistency of the sign, the significance level and coefficients of the competition intensity (Φ_t), the square of the competition intensity (Φ_t^2), and the lagged investment variable ($I_{(t-1)}$). Table 2 displays the estimation results of all models.

Before looking further at the estimation results, it is necessary to first look at the level of validity and the strength of the instrument variables. The non-existence or weak correlation between the instruments and idiosyncratic error indicates the validity of the instruments (Murray, 2006). The Sargan and Hansen tests are generally used to test the validity of an instrument variable. Both tests have a null hypothesis that the instrument is valid. Table 2 shows all p-values of the two tests are higher than 0.05, so that we cannot reject the null hypothesis: i.e. all instrument variables are valid. In addition to the Sargan and Hansen tests, Arrelano and Bond also developed another test to detect the validity of internal instrument variables, i.e. the autocorrelation test on idiosyncratic errors (Roodman, 2009). An estimation result that uses lagged variables as the instrument will lose its consistency when its errors are serially correlated (Arellano & Bond, 1991). In this test, the lagged variable is considered to be a valid instrument if it does not cause serial correlation on idiosyncratic errors. Because this study uses 2-period lagged variables as instrument variables, the autocorrelation test is carried out in order of 2, AR(2). The results show that the six models have p-values of AR(2) higher than 0.05. These indicate the absence of serial correlation on idiosyncratic errors. The next test is to examine the strength of the instruments. We perform this test by looking at the correlation between endogenous variables each with their instrument. The test results show that all internal instrument variables have a significance level of 1%. From all tests, we conclude that all instrument variables are valid and highly correlated with each endogenous variable.

The estimation results in Table 1 show that the variables of interest as a whole have a fairly good level of consistency in terms of significance, sign, and coefficient. In all model specifications, the lagged investment variable ($I_{(t-1)}$) is statistically significant at the level of 1% and 5% with a coefficient value of 0.791 in the model specification 2 and 0.921 in the model specification 6. Similarly, the estimation results of competition intensity (Φ) and the square of competition intensity (Φ^2) are also consistent. The variable Φ has significance levels that vary between 5% and 10%, while significant levels of Φ^2 are consistent at the 5%. However, Φ and Φ^2 consistently show the opposite sign, i.e., positive and negative, respectively. Φ has values that vary between 8.28 in the specification model 4 and 12.43 in the model specification 5. Meanwhile, the coefficients of Φ^2 are in the range of -7.030 in the model specification 4 to -9.543 in the model specification 6. Some control variables are also empirically proved to have a significant effect on investment, which can be seen from the significance level, which varies from 1% to 10%. Those variables are log of population, political stability and quarterly time effects.

Table 2. Estimates

	Model specification					
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Variable of interest						
Log $I_{(t-1)}$	0.811***	0.791***	0.801***	0.788***	0.860***	0.921**
	(0.144)	(0.157)	(0.173)	(0.182)	(0.182)	(0.430)
Φ	10.08**	10.14**	8.785**	8.280*	12.43**	11.64*
	(4.786)	(4.431)	(4.122)	(4.489)	(5.550)	(6.682)
Φ^2	-7.864**	-7.956**	-7.320**	-7.030**	-9.184**	-9.543**
	(3.059)	(2.917)	(2.779)	(3.058)	(3.487)	(4.492)
Control variables						
Cashflow $_{(t-1)}$		-0.443	-0.415	-0.382	-0.212	-0.0080
		(0.515)	(0.478)	(0.409)	(0.493)	(0.124)
Log of population			0.245*	0.261**	0.410***	0.359*
			(0.124)	(0.122)	(0.140)	(0.175)
Log of GDP per capita			0.111	0.138	0.302***	0.252
			(0.160)	(0.168)	(0.0944)	(0.189)

	Model specification					
	(1)	(2)	(3)	(4)	(5)	(6)
Stability				0.261*	0.322***	0.330**
				(0.143)	(0.0960)	(0.158)
Check and balance				-0.0310	-0.0338	-0.0904
				(0.0324)	(0.0324)	(0.0784)
Log FBB subscribers					-0.175	-0.139
					(0.128)	(0.187)
Quarter 2						0.634*
						(0.315)
Quarter 3						0.502**
						(0.228)
Quarter 4						0.872**
						(0.320)
Year effect						√
Constants	0.530	0.908	-4.108**	-4.130**	-8.660***	-8.428**
	(2.085)	(2.054)	(1.584)	(1.769)	(2.995)	(4.064)
N	783	783	783	783	783	783
F test (p-val)	0.000	0.000	0.000	0.000	0.000	0.000
AR2 (p-val)	0.444	0.430	0.417	0.407	0.528	0.782
Hansen-J (p-val)						
Log $I_{(t-3)}$	0.886	0.946	0.936	0.934	0.891	1.000
$\Phi_{(t-2)}$	0.896	0.957	0.916	0.948	0.834	1.000
$\Phi^2_{(t-2)}$	0.865	0.978	0.957	0.984	0.761	1.000
Sargan (p-val)	0.978	0.998	0.998	0.999	0.998	0.462

Standard errors in parentheses
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Short-run effect (SRE) of competition on investment

Model specification 6 is the most complex. It has the most control variables so as to minimize omitted variable bias. We will use this model specification in the further discussions. Refer to equation (3), $\beta 1$ and $\beta 2$ are coefficients of competition intensity and square of competition intensity variables. According to model specification 6, they have values of 11.64 and -9.543, respectively. The short-run effect of an independent variable on the dependent variable is the partial derivative of an estimation against the independent variable (Gujarati, 2003). Thus, the short-run effect (SRE) of competition on investment is a partial derivative of the estimation of investment against competition. Equation (4) is a mathematical expression of the relationship.

$$SRE(\Phi) = \frac{dE(I)}{d\Phi} = \beta_1 + 2\beta_2\Phi = 10.64 - 19.086\Phi \tag{4}$$

The SRE is essentially the marginal effect of the change in the competition intensity on investment. As we observe in equation (4), SRE contains Φ, which means the marginal effect of competition on investment is not linear but depends on the competition level experienced by a company.

Investment maximizing by competition intensity

The difference in the sign between the coefficient of competition variable ($\beta 1$) and the coefficient of square competition variable ($\beta 2$), where $\beta 1$ is positive and $\beta 2$ is negative, indicates a nonlinear relationship between the intensity of competition and investment of an MNO. A quadratic function with a negative quadratic coefficient implies the relationship is inverted-U shaped. In addition to showing nonlinearities, the estimation results also indicate the existence of a point of competition intensity that maximizes investment. We can obtain the value of the point by setting the right-hand side of equation (4) to zero, and we get Φ equal to 0.61. Because competition intensity equals 1-EBITDA margin, the value is equivalent to EBITDA margin of 0.39 or 39%. The interpretation is that initially the increase of competition intensity will encourage MNOs to keep investing. This condition holds until the intensity reaches a point of 0.61 or EBITDA margin at the level of 39%. After this point, MNOs respond negatively to the increase in competition by reducing their level of investment.

Long-run effect (LRE) of competition on investment

Referring to the specification of model 6, the lagged investment variable ($I_{(t-1)}$) has a coefficient of 0.921 and is significant at the level of 1%. The coefficient is less than 1 and more than 0. This implies the adjustment of an investment converges over times. We can use equation 5 to obtain the long-run effect (LRE) and we find that the cumulative impact of competition on investment is 12.5 times that of the short-run.

$$LRE(\Phi) = \frac{1}{(1-\gamma)} SRE(\Phi) = \frac{1}{(1-0.921)} SRE(\Phi) = 12.5\, SRE(\Phi) \tag{5}$$

Discussion

Overall, the findings indicate the coexistence of an escape-competition effect (Arrow Effect) and Schumpeter effect. The escape-competition effect is an attempt by a company to get out of the competition by investing or innovating. In the empirical results above, this effect is shown by companies that experience competition intensity of less than 0.61 or have an EBITDA margin of more than 0.39 (as competition intensity equals 1-EBITDA margin) or 39%. Those companies respond to intense competition by increasing their investment. Meanwhile, the Schumpeter effect is presented by companies having an EBITDA margin of less than 39%. This group faces budget constraints, so that an increase in competition will drive them to reduce their investment.

The findings of this study are in line with that of a study by Mutinda (2016). Mutinda (2016) carried out a study on developing countries at the industry level and used the Herfindahl-

Hirschman Index (HHI) as a measure of competition intensity. The author found an inverted U-curve relationship between competition and investment. Thus, we can conclude that studies at the firm level and at the industry level provide relatively the same results.

The results of this study also complement the study results of Houngbonon & Jeanjean (2016) in two ways. First, Houngbonon & Jeanjean (2016) only included MNOs with positive EBITDA margin, while this study also includes MNOs with negative EBITDA margin. Second, the Houngbonon & Jeanjean (2016) study covers the period 2005 to 2012, when mobile networks were dominated by 2G and 3G technology with very small 4G penetration (eMarketer, 2018). Meanwhile, this study encompasses the period 2009 to 2017. In this time span, mobile broadband technology, as an enabler for OTT services, increased sharply from teledensity of 3 to 53.3 (ITU, 2018), which is expected to give higher and different pressure of competition to the MNOs. However, empirically, the findings of this study and that of Houngbonon & Jeanjean (2016) are very similar, especially in terms of short-run impact. Houngbonon & Jeanjean (2016) also found an inverted U-curve relationship between competition and investment. The EBITDA margin that maximizes investment in this study is in the range obtained in the study of Houngbonon & Jeanjean (2016), which is 37%-40%. This signifies consistent investment behaviour from telecommunications companies in responding to changes in competition intensity. Technological developments do not necessarily change their short-run investment behaviour. However, there is considerably different behaviour of investment in the long run. While Houngbonon & Jeanjean (2016) found the cumulative long-run impact of competition on investment was 3-4 times the short-run, this study finds the impact increases to 12.5 times. This finding is inseparable from the increasingly important role of MNOs in the digital era, which drives mobile network operators to have much longer investment plans than before (GSMA, 2016; WEForum, 2017). Although the digital era causes the massive emergence of OTT service providers that pose threats to MNOs' profitability, as some of them offer substitutions for conventional communication services, the digital era also offers new opportunities in the future. Another justification is that the greater network burden, which is caused by the proliferation of OTT services in the 4G era, has forced telecommunication companies to develop longer-term strategy.

Conclusion

The estimation results show that the intensity of competition has a significant short-run effect on an MNO's investment behaviour. The effect is not linear, but it forms an inverted U curve, which indicates the existence of competition intensity that maximizes investment. We found that the intensity is at the level of 0.61 or when a company has an EBITDA margin of 0.39 or 39%. It means there is a different investment behaviour between companies having EBITDA margins of less than and more than 39% in response to the change in competition intensity. Those whose margin is less than 39% respond to an increase in the competition intensity by reducing their investment. Meanwhile, operators with an EBITDA margin of more than 39% respond in the opposite way. The empirical results also show the cumulative impact of the intensity of competition on investment in the long-run is 12.5 times of the short-run. These results in some respects have shown very similar results as previous works, especially for short-run impact.

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