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The impact of 5G multi-access edge computing cooperation announcement on the telecom operators' firm value

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Abstract

Since multi-access edge computing (MEC) was established as a key enabler of 5G, MEC based on 5G networks (5G MEC) has been perceived as a new business opportunity for many industry players, including telecom operators. Numerous 5G MEC cooperation announcements among companies playing their respective roles in the MEC ecosystem have been recently released. However, because of cooperative and competitive relationships among key players in the MEC ecosystem and the uncertainty of 5G MEC, the announcement of 5G MEC cooperation can negatively affect the telecom operators' firm value. This study investigates the market reaction to announcements of 5G MEC cooperation for telecom operators using an event study methodology. The empirical results show that announcements of 5G MEC cooperation have a negative impact on the telecom operators' firm value. The results also show that the early deployment of 5G networks may reduce the negative impact of 5G MEC cooperation announcements by reducing uncertainty.

KEYWORDS

5G, event study, innovation uncertainty, multi-access edge computing, strategic alliances

1 | INTRODUCTION

Since the first commercialized 5G service in early 2019, mobile communication services have started to transition from 4G to 5G. While the evolution of mobile communication services from 1G to 4G was focused on the increase in transmission speed and coverage, 5G is not only focused on the advancement of transmission speed (enhanced mobile broadband [eMBB]) but also the technology supporting massive machine-type communication (mMTC) and ultra-reliable low-latency communication (URLLC). Due to these technological characteristics, 5G is expected to be used in various vertical and business-to-business (B2B) markets, whereas past mobile communication services were focused mainly on business-to-customer (B2C) and mobile broadband [1,2]. In this way, 5G will play an important role in boosting the digital economy as an infrastructure.

Although the expectations of a socioeconomic ripple effect of 5G have attracted the attention of governments and markets, the existing centralized network architectures have physical limitations for satisfying the performance requirements of the 5G B2B use case, in particular, ultralow latency. Despite the fact that ultralow latency is realized at the wireless transmission level, the physical distance between the core network and the base stations is another challenge for end-to-end ultralow latency. The multi-access edge computing (MEC) technology was introduced to overcome these limitations and realize the technological potential of 5G, including

eMBB, mMTC, and URLLC. The concept of MEC was introduced by the European Telecommunications Standards Institute (ETSI) Mobile Edge Computing Industry Specification Group (MEC iSG) at the end of 2014, and the meaning of the abbreviation MEC was changed to signify multi-access edge computing to encapsulate the additional benefits of heterogeneous access technologies, such as 4G, 5G, Wi-Fi, and fixed access [3]. According to the ETSI, MEC is the technology that "offers application developers and content providers cloud-computing capabilities and in IT service environment at the edge of the network." In simple terms, MEC is a concept that minimizes the latency of the backhaul network and the bottleneck in the core network by building edge computing resources at the network edge. It implies that latency-sensitive 5G-based services and applications can be processed at the network edge without passing through a core network or public cloud server located far from base stations. In this context, Antony Franklin and Tambe [4] explained that MEC has become one of the key enablers of 5G as an enhancement of network performance by reducing latency and optimizing the backhaul traffic. Moreover, MEC platforms provide an environment for application developers to develop MEC-based 5G applications and enables them to distribute the applications to the network edge. Therefore, MEC platforms will play an intermediating role between application developers and customers at the network edge.

As a key enabler of 5G, MEC based on 5G networks (5G MEC) has been perceived as a new business opportunity for various industry players, including telecom operators, creating new vertical markets, such as industrial automation, autonomous vehicles, and cloud gaming. The 5G Infrastructure Public Private Partnership (5G PPP) [5] anticipates that many players, such as telecom operators, Hyperscalers[1] (e.g., AWS, Microsoft, and Google), and global IT solution providers (e.g., IBM and HPE) will participate in the 5G MEC market. It is an especially great opportunity for telecom operators to diversify their business model and transition from network service providers to platform companies generating revenue from vertical markets by extending edge cloud resources to the network edge [7]. According to 5G PPP [5], cooperation between key players in the MEC ecosystem, such as telecom operators and Hyperscalers, is a meaningful scenario which combines each player's expertise. For example, cooperating with Hyperscalers is necessary for attracting application developers because many application developers are familiar with Hyperscalers' API, and Hyperscalers can provide the same development environment globally, regardless of the region. Similarly, cooperating with telecom operators is necessary for Hyperscalers so that they can use the operators' network edge assets. Indeed, there have been many recent 5G MEC cooperation announcements between key service providers. However, based on this strength point of Hyperscalers, there is also a possibility that Hyperscalers will come to occupy a prominent position in the market by decreasing the telecom operators' role at the edge [5,8]. In this case, the role of telecom operators is limited to lending their network assets, and Hyperscalers will operate their MEC platform on the telecom operators' network infrastructure. For the abovementioned reasons, 5G PPP [5] anticipates that the relationships of MEC ecosystem players will be cooperative and competitive (hereafter referred to as coopetitive).

5G MEC cooperation may, however, have a negative impact on telecom operators due to the inherent uncertainty. While the deployment and expansion of the coverage of 5G networks has been undertaken with huge investment, 5G has so far focused on the B2C market, as has been the case with previous mobile services; the B2B market demand remains uncertain. In this market environment, event announcements related to 5G MEC may be perceived as negative at least in the short-term. Jeon and others [9] showed that announcements of 5G R&D investment impact negatively on the firm value due to the uncertainty of the 5G market.

As a key enabler of 5G, 5G MEC is expected to play an important role in creating new markets and business opportunities, but there are some risks for telecom operators, such as coopetitive relationships and uncertainty regarding the 5G MEC market. Considering the importance of 5G MEC, it is expected that the announcement of 5G MEC cooperation will have a significant impact on the telecom operators' firm value as such an announcement signals that telecom operators are actively participating in the 5G MEC business. As mentioned above, 5G MEC cooperation has both positive and negative sides; thus, the impact on the telecom operators' firm value can be either positive or negative depending on the views of markets. To vitalize the 5G-MEC ecosystem as a measure to promote the socioeconomic ripple effect of 5G, investments into 5G network infrastructure deployment and MEC by telecom operators are necessary. However, the uncertainties related to the 5G-MEC market, including the coopetitive environment, may be an obstacle for promoting the MEC ecosystem because it disrupts the investment incentive of telecom operators regarding MEC and 5G network infrastructure. Therefore, studying the uncertainty and risks for telecom operators when participating in the 5G-MEC market is important. Assuming

[1]Hyperscalers are massive cloud companies that try not only to dominate the cloud services industry but also to expand their business to related verticals [6].

that the negative market reaction is related to uncertainty and risk, the uncertainty related to 5G MEC market can be identified by investigating the market reaction to the 5G MEC cooperation announcement. Therefore, this study examines whether 5G MEC cooperation announcements have any impact on the value of the telecom operators. This study also investigates whether a telecom operator having a relationship with Hyperscalers has an influence on the effect of a 5G MEC cooperation announcement and how the uncertainty of the 5G MEC business affects the response to an announcement of 5G MEC cooperation. This study used the event study methodology for capturing the impact of a 5G MEC cooperation announcement on the telecom operators' firm value. This methodology has been widely used in previous studies for measuring the impact of events on firm value in the telecommunication industry [10,11] and the impact of strategic alliances announcements on firm value [12,13]. This study also conducted a regression analysis to investigate the combined effect of a coopetitive relationship and innovation uncertainty on the impacts of the 5G MEC cooperation announcement. This study is organized as follows: After reviewing previous studies related to the impact of cooperation in Section 2, this study presents the research methodology and data in Section 3. Section 4 represents the empirical results, and the conclusions of this study are given in Section 5.

2 | LITERATURE REVIEW

2.1 | The benefits of cooperation in 5G MEC for telecom operators

This study views 5G MEC cooperation as a strategic alliance as this implies the cooperation of more than two companies toward achieving specific goals [14,15]. Elmuti and Kathawala [16] explained that the aims of a strategic alliance are to use such an alliance as a growth strategy, to enter a new market, to share risks and costs of R&D, or to achieve or secure strategic advantages effectively. Cuéllar-Fernández and others [13] summarized previous studies indicating that the benefits of a strategic alliance include the potential for creating value by accessing new resources, the reduced transaction costs by acquiring the capabilities enabling rapid and flexible response to change in the demand and structure of the industry, and the secure guarantee for third parties, especially in the case of small firms. If these benefits of strategic alliances are expected to affect the firm's present and future cash flow positively, the announcement of a strategic alliance will have a positive impact on the firm's stock price [13]. In this regard, previous studies empirically showed that a strategic alliance announcement has a positive impact on the firm value [14,15,17–20].

There also exist some studies focused on the impact of technological alliances on the firm value and the difference between the impact of technological alliances and marketing alliances. The advantages of a technological alliance include the flexible development of technologies using resources effectively, accessing the partner company's technologies and core competencies, and enabling a company to expand its range of products or services or enter new markets [12,14]. In this regard, [15,17,21] showed that technological alliances create more value than nontechnical alliances. Neill and others [14] also found that information technology alliance announcements have a positive impact on the firm value. However, there are also studies that found that there was no statistical significance of the impact of technological alliances on the firm value in all samples [12,13]; [12] explained that this might be due to the heterogeneity of firms and alliances that can impact on the firm value differently.

Considering the general purposes of a strategic alliance, mentioned by other studies [13–16], the purposes of taking part in 5G MEC alliances between telecom operators might be to enter a new market (such as B2B vertical markets), share the risks and costs of R&D related to 5G MEC, and/or secure reliability in cloud computing where telecom operators have a lack of expertise compared with global partners. 5G MEC cooperations can be classified as a technological alliance because the aim of such an alliance is the development and testing of MEC technologies and/or solutions in general. In line with this, 5G MEC cooperation announcements can impact the telecom operators' firm value positively due to the expectation of advantages arising from such alliances. However, as Bayona and others [12] notes, the impact of 5G MEC cooperation announcements can be affected by the nature of the firm and/or alliance characteristics.

2.2 | The risks of 5G MEC cooperation for telecom operators

There are also inherent risks in strategic alliances; these risks include a lack of communication between partner firms, opportunistic behavior of partner firms, and clashes of interests between partners [12,16]. Owing to these risks, some previous studies empirically showed that strategic alliance announcements have a negative impact on the value of a firm [22,23]. This study focused on the risks of strategic alliances between potential rivals and identified risks of 5G MEC cooperation. Elmuti and

Kathawala [16] noted that strategic alliances have potential risks related to the relational risk and the risk of creating potential competitors. The relational risk is related to the possibility of undermining the prospects of alliance due to the partner firms' opportunistic behavior and a lack of commitment to alliances. The risk of creating potential competition is related to the likelihood that the partner firm might be using the alliance to test a market and prepare the launch of its own services. Based on the transaction cost theory, Ybarra and Turk [24] argued that strategic alliances with direct competitors are negatively related to the firm's value due to the additional costs of monitoring the partner firm to prevent opportunistic behavior; this study empirically showed that these strategic alliances have a negative impact on the firm value. In the 5G MEC ecosystem, the relationship between players, including telecom operators, can be described as being of coopetition, as mentioned in the introduction. Each player cooperates within the ecosystem performing a given role, but at the same time competes for a prominent position in the market. For this reason, partner firms engaged in 5G MEC cooperation may also act as potential competitors and show opportunistic behavior. This represents a risk in 5G MEC cooperation agreements for telecom operators.

Participating in 5G MEC cooperation can also be viewed as an innovation activity. Sood and Tellis [25] classified such alliances as one of the initiation stages of innovation activities. Generally, previous studies have showed that the initiations of innovation activities have a positive impact on the firm value [21,25,26]. However, Kelm and others [27] showed that the initial stages of innovation activities may impact the firm value negatively due to the high cost of such activities and uncertainty. Woolridge and Snow [28] also predicted that the long-term and uncertain strategic investment decisions can be associated with negative market return based on the institutional investor hypothesis. In this regard, Jeon and others [9] investigated the market reaction to a telecom operator's 5G activities modeling such collaborations as innovation activities with high uncertainty and empirically showed that 5G R&D and investment activity announcements have a negative impact on the firm value. Compared with the 5G R&D and investment activity, 5G MEC cooperation may be regarded as involving higher innovation uncertainty for telecom operators. Jalonen [29] observed that the technological uncertainty and market uncertainty form part of the uncertainty associated with innovation. The author summarized that technological uncertainty is related to a lack of knowledge about the details of a new technology or a lack of knowledge regarding the use of a new technology. This uncertainty may be related to the telecom operators' lack of expertise in edge computing. The market uncertainty is related to an uncertain market demand and uncertainty regarding the behavior of competitors. The possibility that the partner firm can be a potential competitor may also increase market uncertainty. It also seems that the market demand for 5G MEC is less clear than the existing 5G markets; this is highlighted by the fact that the 5G MEC market has not yet been established.

To summarize, an announcement of 5G MEC cooperation may have either positive, negative, or insignificant impacts on a telecom operator's firm value because there are both benefits and risks associated with such an announcement. Considering a telecom operator's lack of expertise and experience in the field of edge computing and B2B applications (compared with their main business areas, such as mobile services and B2C), this study assumes that the negative effects may be more significant than the positive effects, at least in the short term. Following this assumption, this study proposes the first hypothesis below:

H1. The announcement of 5G MEC cooperation has a negative impact on the telecom operators' firm value.

This study also assumes that cooperation with Hyperscalers and the telecom operator's region/country of origin may affect the impact of a 5G MEC cooperation announcement. Considering Hyperscalers' relatively large influence in the 5G MEC ecosystem and its status as a key player in the field, a coopetitive relationship between Hyperscalers and telecom operators may be different to cooperation announcements between companies in other sectors. For instance, in the case of announcements involving potential competitors, cooperation with Hyperscalers may be more negative than other similar announcements. When the benefit from Hyperscalers' expertise and experience is larger than other factors, the cooperation with Hyperscalers may be more positive than such an announcement with alternative companies. The telecom operator's region/country of origin can also be related to the degree of uncertainty regarding 5G MEC cooperation. According to ETNO Association [30], the population coverage of 5G (coverage by at least one operator, 3Q 2020) in South Korea and the United States are 93.0% and 76.0%, respectively, which is much higher than that in countries such as Japan (34.3%) and the EU (24.4%). Inderst and Peitz [31] noted that investments in next-generation access networks are associated with uncertainty regarding the success of such investments. From this perspective, the telecom operators in regions leading 5G investment such as achieving high 5G network coverage may be seen to be operating in conditions of less uncertainty regarding 5G-related markets

than those in other regions/countries. The relatively early deployment of the 5G infrastructure itself may also reduce the uncertainty related to 5G MEC. Considering the difference in deployment levels of 5G networks, 5G MEC cooperation may be perceived as innovation activities with less uncertainty in high 5G coverage regions/countries. Following these assumptions, this study proposes the second and third hypotheses below:

H2. The impact of a 5G MEC cooperation announcement on the telecom operators' firm values is differentiated depending on whether the partner firm is Hyperscalers or not.

H3. The telecom operators in regions/countries with more advanced 5G deployment experience less negative market reaction to 5G MEC cooperation announcement events.

3 | METHODOLOGY

3.1 | Data

This study defines the event as the public announcement of 5G MEC cooperation in the media. As can be seen from the cases of Amazon AWS Wavelength cooperation announcements, 5G MEC cooperation is being actively conducted principally in four regions/countries: the EU, Japan, South Korea, and the United States. This study therefore focuses on telecom operators' 5G MEC cooperation announcements in four regions/countries. 5G MEC cooperation announcements with enterprise customers or application providers are excluded from this study because the interest of this study is the coopetitive relationship among telecom operators and other players, such as Hyperscalers, IT solution providers, and network equipment providers. The event data are collected from 5G MEC-related news in the press release pages of corporate websites and related news sources from 2019 to 2020. This study finds 24 such announcements during that period; six announcements are excluded because those events are cases in which one telecom operator announced more than one 5G MEC cooperation agreement on the same day or on the consecutive days; these announcements are excluded as the impact of the announcements may be diluted due to the proximity of the events[2]. The final sample thus consisted of 18 announcements related to 10 telecom operators, and the total number of events is 31 because some cooperation announcements include more than one telecom operator. Table 1 shows the details of the announcements of 5G MEC cooperation included in this study.

[2]The six events include cooperation announcements regarding AT&T—IBM (2019-07-16); AT&T—Microsoft (2019-07-17); Telefonica Deutschland—Amazon (2020-09-01); Telefonica Deutschland—Ericsson (2020-09-01); and Verizon—Microsoft (2020-10-19); Verizon—Nokia (2020-10-20).

3.2 | Methodology: Event study

This study uses the event study methodology to assess the impact of the announcement of MEC cooperation on a telecom operator's firm value. The event study methodology is based on the semistrong form of the efficient market hypothesis. This hypothesis assumes that the stock price of a company reflects all publicly available information. Following this hypothesis, the particular public event should have a significant impact on stock prices. If information leakage occurs, the market reaction will appear before the event announcement, and abnormal fluctuations in the stock price may appear several days before the announcement. It is also noted that the impact of an event may appear several days after the announcement date, and it may last for days. However, these behaviors do not occur in all events. This study estimates the abnormal returns of telecom operators due to the announcement of 5G MEC cooperation events using a statistical market model. The market model assumes that the return of any given security is related to the return of market portfolio. For any security i the market model is as follows.

$$E(R_{it}) = \alpha_i + \beta_i R_{mt} + e_{it}. \quad (1)$$

Here, $E(R_{it})$ and R_{mt} are the expected return of security i and the corresponding return of the market portfolio at time t. The terms a_i and b_i are the parameters of the market model, and e_{it} is an error term. The abnormal returns are calculated from the difference between the actual return of security i and the expected return of security i derived from the market model.

$$AR_{it} = R_{it} - (\alpha_i + \beta_i R_{mt}), \quad (2)$$

where AR_{it} and R_{it} are the abnormal and actual return of the security i at time t, R_{mt} is the corresponding return of the market portfolio at time t. The parameter α_i and β_i are calculated from the ordinary least-squares (OLS) regression method with daily return of security i and corresponding market index for an estimation period from 210 to 10 days ($t = -210, -10$) before the

TABLE 1 5G multi-access edge computing (MEC) cooperation announcement dates and related firms

Dates	Related telecom operators[a]	Related non-telecom operators
2019-05-01	Orange	Dell
2019-06-19	AT&T	HPE
2019-10-24	Verizon	SAP
2019-12-03	KDDI, SK Telecom, Verizon, Vodafone	Amazon
2020-01-13	SK Telecom, etc.	-
2020-01-17	KT, Verizon, Vodafone, etc.	-
2020-02-27	Deutsche Telekom, KDDI, Orange, SK Telecom, Telefonica, etc.	-
2020-03-04	KT, Telefonica, etc.	-
2020-03-05	AT&T	Google
2020-03-31	SK Telecom, Telefonica, Vodafone, etc.	Microsoft
2020-06-11	Telefonica	Google
2020-07-16	Verizon	IBM
2020-07-21	SK Telecom	HPE
2020-07-28	Orange	Google
2020-09-21	LGU+	Google
2020-10-12	Verizon	Cisco
2020-10-14	AT&T	IBM
2020-11-09	Deutsche Telekom, SK Telecom	-

[a]Telecom operators not subjected to the analysis are omitted at the table.

announcement date ($t = 0$)[3]. If the unexpected event occurs on day t, there may be an abnormal return of security i around that day. The total impact of the event on security i can then be calculated by cumulative abnormal return (CAR) in a period surrounding the event date, called event window as follows:

$$CAR_i = \sum_{t=t_1}^{t_2} AR_{it}, \tag{3}$$

where $t_1 \leq t_0$ (event date) $\leq t_2$ and t_1 to t_2 is called the event window. This study used the market indices NYSE, FTSE 100, DAX, CAC 40, IBEX 35, NIKKEI 225, and KOSPI for the United States, the United Kingdom, Germany, France, Spain, Japan, and South Korea, respectively. The security and market index data were collected from the *Wall Street Journal* and *KRX*.

This study conducts a univariate analysis to investigate whether the overall CARs are statistically different from zero (H1). To investigate the effect of cooperation with Hyperscalers (H2) and the effect of 5G network deployment level in telecom operator's home regions/country (H3), this study classifies the CARs as follows: To test H2, the overall CARs are classified according to whether the 5G MEC cooperation announcement partner firm is Hyperscalers or not. Hyperscalers include Amazon, Microsoft, and Google following the classification of 5G PPP [5]. To test H3, the overall CARs are classified as to whether the 5G MEC cooperation announcements concern telecom operators in countries and regions that have achieved a high 5G coverage. Based on the 5G coverage level collected from ETNO Association [30], this study classified South Korea and the US as high-5G coverage countries and regions. Thus, AT&T, Verizon, KT, LGU+, and SKTelecom were classified as telecom operators in high-5G coverage countries and regions. A multivariate analysis was also conducted to investigate the combined effects of the variables related to H2 and H3, controlling for firm characteristics.

[3]The length of the estimation period differs depending on the study, but it is usually around 100 to 300 days. Previous studies [25, 32], which used event windows around two days from the event date, chose the length of the estimation period to be around 200 days. In general, the estimation period should not overlap with the event window. Thus, this study chose an estimation period from 210 to 10 days before the announcement date.

4 | RESULTS

4.1 | Univariate analysis

The overall results of the univariate analysis are presented in Table 2. The first finding of the empirical results

TABLE 2 Cumulative abnormal return (p-value) results

CAR window[a]	Overall 5G MEC cooperation announcement		
(0, 1)	−0.005 (0.170)		
(−1,1)	−0.009** (0.048)		
(−2,1)	−0.011** (0.020)		
N	31		
CAR window	**Without Hyperscalers**	**With Hyperscalers**	**Difference**
(0, 1)	−0.006 (0.150)	−0.001 (0.815)	−0.005 (0.448)
(−1,1)	−0.011** (0.047)	−0.004(0.574)	−0.007 (0.437)
(−2,1)	−0.013** (0.025)	−0.006(0.420)	−0.007 (0.447)
N	20	11	
CAR window	**High 5G coverage regions/country**	**Other regions/country**	**Difference**
(0, 1)	0.003 (0.448)	−0.013** (0.011)	0.016*** (0.009)
(−1,1)	0.002 (0.662)	−0.021*** (0.001)	0.023***(0.005)
(−2,1)	0.000 (0.950)	−0.024*** (0.006)	0.023*** (0.006)
N	17	14	

[a]A cumulative abnormal return (CAR) window (t_1, t_2) denotes the event window ranges from t_1 day before the event date to t_2 days after the event date.
*$p < 0.1$. **$p < 0.05$. ***$p < 0.01$.

is that 5G MEC announcements have a negative impact on the telecom operators' firm value overall, and these results are statistically significant for the CAR windows (−1, 1) and (−2, 1) at the 5% significance level, which supports H1. One possible explanation of this result is that the market or investors may perceive that the negative side of 5G MEC cooperation (such as a partner firm engaging in opportunistic behavior, the uncertainty of success, or the risk of increasing costs) is more significant than the potential positives.

Second, the empirical results show that there is not a statistically significant difference in the impact of a 5G MEC cooperation announcement involving Hyperscalers and one not involving Hyperscalers. CARs related to 5G MEC cooperation announcements without Hyperscalers are negative at the 5% and 10% significance levels for the CARs windows (−2, 1) and (−1, 1), respectively; this is in contrast with announcements involving Hyperscalers, which are statistically insignificant for all CAR windows. This result may be explained by the fact that the negative impact is diluted by the benefits of cooperation with Hyperscalers; however, this finding does not constitute strong evidence supporting H2. This result implies that the fact that cooperation with Hyperscalers does not affect the impact of 5G MEC cooperation announcement at least more negatively. It can be interpreted that the positive point of cooperation with Hyperscalers such as ensuring service compatibility, attracting application developers and enterprise customers familiar with Hyperscalers' API, and the advantage of using Hyperscalers' renown and expertise outweigh the risks from potential competition.

Third, we note that the results imply that uncertainty may be a key factor in explaining the negative impact of 5G MEC cooperation on telecom operators. There are statistically significant differences between the effect of announcements of telecom operators in high 5G coverage regions/countries and those of telecom operators in other regions/countries (at least at the 10% significance level for all events). In particular, the difference is statistically significant at the 1% significance level for the CAR windows (−1, 1) and (−2, 1). Telecom operators in other regions/countries experienced a negative impact of announcement at least at the 5% significance level, whereas telecom operators in high 5G coverage regions/countries did not experience statistically significant impacts. This result suggests that the uncertainty of innovation activities related to 5G MEC may be reduced to some degree in high 5G coverage regions/countries which can be an indicator of less uncertainty regarding 5G-related markets. From a different perspective, high 5G coverage itself may reduce the uncertainty because 5G MEC is depending on 5G network infrastructure. This result supports H3.

To summarize the results of the univariate analysis: First, the market or investors perceived 5G MEC cooperation as negative, at least in short-term. The negative impact of 5G MEC cooperation was found to be reduced; however, in high 5G coverage regions/countries. This result suggests that the main factor deciding the impact of 5G MEC cooperation announcements may be the

uncertainty related to 5G because the negative effect is eased in high 5G coverage regions/countries, which can be interpreted as less uncertainty environments.

4.2 | Multivariate analysis

This study also conducted a regression analysis to investigate the combined effect of firm characteristics alongside factors related to H2 and H3. Following previous studies [9,13,33], this work takes into account three firm-specific characteristics: firm size, market-to-book ratio, and leverage. These are widely used as the determinants of the magnitude of abnormal returns. The firm size is related to the impact of the cooperation announcement on firm value for the following reasons. First, the abnormal returns for small firms can be expected to be higher due to the possibility of spillover from the reputation of large firms to small firms [34]. Similarly, Austin [35] suggests that the abnormal returns for small firms are higher because the degree of salience of any single event is higher for small firms than large firms. The market-to-book ratio is also related to the impact of the cooperation announcement as a proxy for growth opportunity. A high market-to-book ratio implies a comparably low growth opportunity, whereas Cuéllar-Fernández and others [13] showed that a low market-to-book ratio positively affects the impact of strategic alliance announcements on firm value. Leverage is used for the control variable to investigate the impact of the cooperation announcement as a proxy for a firm's level of financial distress. This study measures the firm size as the natural logarithm of the total assets; the market-to-book ratio is measured as the market capitalization divided by the book value, whereas the leverage is measured by the total debt divided by the total assets. This study also uses a dummy variable related to H2, which contains information related to cooperation with Hyperscalers. When the event is related to cooperation with Hyperscalers, the Hyperscalers dummy variable is 1. Lastly, 5G coverage data collected from ETNO [30] is used to investigate whether the 5G deployment level of telecom operators regions/countries affect to the impact of 5G MEC cooperation announcement (H3). Descriptive statistics is summarized in Table 3.

According to Table 4, the multivariate results show that there are no statistically significant variables except for the 5G coverage variable that satisfies the 1% and 5% significance levels for all CAR windows. This result also supports H3, which is consistent with the univariate analysis, but it is inconsistent with Cuéllar-Fernández and others [13], which showed that the impact of

TABLE 3 Descriptive statistics

variables	*N*	Mean	Median	Std. Dev.	Min	Max
Firm size	31	18.582	18.645	0.974	16.555	20.104
Market-to-book ratio	31	1.421	1.223	1.031	0.438	3.637
Leverage	31	0.371	0.408	0.112	0.173	0.503
Hypersclaers dummy	31	0.355	0	0.486	0	1.000
5G coverage	31	0.490	0.530	0.320	0.172	0.930

Note: This table describes the summary statistics of the sample. The dataset consisted of 31 cumulative abnormal returns (CARs) involving 10 telecom operators.

TABLE 4 Cross-sectional regression results of cumulative abnormal return (CAR) (*p* value) with control variables

Variables	CAR (0, 1)	CAR (−1, 1)	CAR (−2, 1)
Firm size	0.002 (0.664)	0.007 (0.262)	0.004 (0.563)
Market-to-book ratio	0.000 (0.952)	−0.002 (0.698)	0.004 (0.460)
Leverage	0.057 (0.146)	0.051 (0.304)	0.051 (0.335)
Hyperscalers dummy	0.008 (0.181)	0.012 (0.147)	0.012 (0.156)
5G coverage	0.041*** (0.005)	0.057*** (0.003)	0.052*** (0.008)
Constant	−0.089 (0.302)	−0.184 (0.102)	−0.132 (0.261)
Observations	31	31	31
F value	2.554* (0.053)	2.824** (0.037)	2.660** (0.046)
Adjusted R^2	0.206	0.233	0.217

*$p < 0.1$. **$p < 0.05$. ***$p < 0.01$.

strategic alliances of telecom operators are related to firm characteristics. This result implies that the uncertainty regarding 5G-related innovation activities may be the most important factor in explaining the negative impact of 5G MEC cooperation announcements.

5 | CONCLUSIONS

This study investigated the impact of 5G MEC cooperation announcements on the telecom operators' firm value. In accordance with previous studies, this work assumes that 5G MEC cooperation announcements have a negative impact on the telecom operators' firm value, and the negative impact is related to coopetitive relationships and innovation uncertainty. The empirical results of this study show that announcements of 5G MEC cooperation have a negative impact on telecom operators. This study also finds that telecom operators in high 5G coverage regions/countries suffered less severe negative impacts from 5G MEC cooperation announcements. This result implies that the innovation uncertainty regarding 5G MEC may be reduced in active 5G investment environments. However, this study does not find statistically strong evidence regarding whether cooperation with Hyperscalers influences the impact of 5G MEC announcements. This result indicates that coopetitive relationships with Hyperscalers in the 5G MEC ecosystem may not be solely a negative for telecom operators. Moreover, the multivariate analysis results show that 5G coverage variables is the only statistically significant variable. It can thus be inferred that innovation uncertainty is a dominant factor explaining the negative impact of 5G MEC cooperation announcements on telecom operators.

The results of this study have several implications. Even though 5G MEC is perceived as a key enabler of 5G, shareholders of telecom operators seem to be worried about uncertainty. An interesting point of this study is that the 5G coverage level of a telecom operator's region/country can reduce the negative impact of cooperation announcements. Considering that a high-5G coverage level is an indicator of less uncertainty related to a 5G investment, it can be important to provide a relatively low-uncertainty environment to ease shareholders' negative views on telecom operators participating in innovation activities related to 5G, including 5G MEC. In this regard, for policy makers, introducing measures to support 5G-related innovation activities for market participants, including telecom operators, can be regarded as a method to promote the 5G-related ecosystem in its early stages by reducing uncertainty. For example, the South Korean government announced a plan for vitalizing MEC-based 5G services in early 2021 that included the preemptive investment in and the creation of a foundation for market participation as a means of promoting the 5G-related ecosystem. From another perspective, high-5G coverage itself may reduce the uncertainty related to 5G-related innovation activities as a proxy for high 5G readiness. In this regard, it can be said that the early deployment of 5G network infrastructure plays a key role in 5G related innovation activities. The other implication is related to the coopetitive relationships in the 5G MEC ecosystem. Contrary to some perspectives that are concerned about the possibility of the emergence of strong competitors, shareholders do not perceive that cooperation with Hyperscalers is more negative than cooperation with other companies. From the perspective of shareholders, it seems that cooperation with renowned Hyperscalers reduces uncertainty regarding edge-computing business opportunities. Hence, 5G MEC cooperation with globally renowned companies, including Hyperscalers, can be regarded as one way to protect the shareholder value by reducing the uncertainty of 5G MEC despite the coopetitive MEC ecosystem. As 5G is expected to be used in various verticals and B2B markets, strategic alliances among telecom operators that want to expand their business area and other companies that want to provide innovative services based on 5G are expected to be similar to those formed in the case of 5G MEC cooperation. Based on the results of this study, it can be recommended that telecom operators focus on the benefits from cooperation partners rather than the possibility of potential competition with partners when they consider strategic alliances.

This study has several limitations. First, the number of samples is insufficient to provide strong evidence compared with previous studies because of the short history of 5G MEC technology. Second, this study only focused on the telecom operators' firm value, although there are other key players in the MEC ecosystem. Further research may provide more insights by analyzing the impact of MEC activities on all players in the MEC ecosystem, including the effect of their role and coopetitive relationships.

CONFLICT OF INTEREST

The author declares that there are no confilcts of interest.

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REFERENCES

1. K. Campbell, J. Diffley, B. Flanagan, B. Morelli, B. O'Neil, and F. Sideco, *The 5G economy: how 5G technology will contribute to the global economy*, IHS Economics & IHS Technology, 2017, pp. 1–34.

2. Ericsson, *The 5G business potential*, second edition, industry digitalization and the untapped opportunities for operators, 2017.
3. Q.-V. Pham, F. Fang, V. N. Ha, M. J. Piran, M. Le, L. B. Le, W.-J. Hwang, and Z. Ding, *A survey of multi-access edge computing in 5G and beyond: fundamentals, technology integration, and state-of-the-art*, IEEE Access **8** (2020), 116974–117017.
4. A. Antony Franklin and S. D. Tambe, *Multi-access edge computing in cellular networks*, CSI Trans. ICT **8** (2020), 85–92.
5. 5G Infrastructure Public Private Partnership Edge computing for 5G networks. version 1.0, 2021.
6. J. Borker, *What is hyperscale?* 2017, Available from: https://www.digitalrealty.com/blog/what-is-hyperscale [last accessed October 2021].
7. J. Bright, *Driving new business opportunities with multi-access edge computing and 5G*, 2019.
8. M. Ivezic, *Will telcos lose the edge computing battle as well?* 2020, Available from: https://5g.security/5g/will-telcos-lose-the-edge-computing-battle-as-well/ [last accessed May 2021].
9. C. Jeon, S. H. Han, H. J. Kim, and S. Kim, *The effect of government 5G policies on telecommunication operators firm value: Evidence from china*, Telecommun. Policy **46** (2022), no. 2. https://doi.org/10.1016/j.telpol.2020.102040
10. M.-C. Park, D.-H. Yang, C. Nam, and Y.-W. Ha, *Mergers and acquisitions in the telecommunications industry: myths and reality*, Etri J. **24** (2002), no. 1, 56–64.
11. M. Cohen-Meidan, *The effects of standardization process on competition: an event study of the standardization process in the us cable modem market*, Telecommun. Policy **31** (2007), no. 10–11, 619–631.
12. C. Bayona, P. Corredor, and R. Santamaría, *Technological alliances and the market valuation of new economy firms*, Technovation **26** (2006), no. 3, 369–383.
13. B. Cuéllar-Fernández, Y. Fuertes-Callén, and J. A. Laínez-Gadea, *The impact of strategic alliances on the market value of telecommunications firms*, J. High Technol. Manag. Res. **22** (2011), no. 1, 1–13.
14. J. D. Neill, G. M. Pfeiffer, and C. E. Young-Ybarra, *Technology R&D alliances and firm value*, J. High Technol. Manag. Res. **12** (2001), no. 2, 227–237.
15. S. H. Chan, J. W. Kensinger, A. J. Keown, and J. D. Martin, *Do strategic alliances create value?* J. Finance Econ. **46** (1997), no. 2, 199–221.
16. D. Elmuti and Y. Kathawala, *An overview of strategic alliances*, 2001. Management decision.
17. S. Campart and E. Pfister, *The value of interfirm cooperation: an event study of new partnership announcements in the pharmaceutical industry*, in Proc. 57th Eur. Meeting Econometric Soc. (Venice, Italy), Aug. 2002.
18. J. Brooke and B. Oliver, *The source of abnormal returns from strategic alliance announcements*, Pacific-Basin Finance J. **13** (2005), no. 2, 145–161.
19. K. Kalaignanam, V. Shankar, and R. Varadarajan, *Asymmetric new product development alliances: win–win or win–lose partnerships?* Manag. Sci. **53** (2007), no. 3, 357–374.
20. H. Lee, E. Cho, C. Cheong, and J. Kim, *Do strategic alliances in a developing country create firm value? Evidence from Korean firms*, J. Empir. Finance **20** (2013), 30–41.
21. S. Das, P. K. Sen, and S. Sengupta, *Impact of strategic alliances on firm valuation*, Acad. Manag. J. **41** (1998), no. 1, 27–41.
22. I. Lee and S. B. Wyatt, *The effects of international joint ventures on shareholder wealth*, Finance Rev. **25** (1990), no. 4, 641–649.
23. I. Y. Chung, K. J. Koford, and I. Lee, *Stock market views of corporate multinationalism: some evidence from announcements of international joint ventures*, Quart. Rev. Econ. Finance **33** (1993), no. 3, 275–293.
24. C. E. Ybarra and T. A. Turk, *Strategic alliances with competing firms and shareholder value*, J. Manag. Mark. Res. **6** (2011), 1.
25. A. Sood and G. J. Tellis, *Do innovations really pay off? Total stock market returns to innovation*, Mark. Sci. **28** (2009), no. 3, 442–456.
26. J. Doukas and L. Switzer, *The stock market's valuation of R&D spending and market concentration*, J. Econ. Bus. **44** (1992), no. 2, 95–114.
27. K. M. Kelm, V. K. Narayanan, and G. E. Pinches, *Shareholder value creation during R&D innovation and commercialization stages*, Acad. Manag. J. **38** (1995), no. 3, 770–786.
28. J. R. Woolridge and C. C. Snow, *Stock market reaction to strategic investment decisions*, Strateg. Manag. J. **11** (1990), no. 5, 353–363.
29. H. Jalonen, *The uncertainty of innovation: A systematic review of the literature*, J. Manag. Res. **4** (2012), no. 1. https://doi.org/10.5296/jmr.v4i1.1039
30. ETNO Association, *The state of digital communications 2021*, 2021.
31. R. Inderst and M. Peitz, *Investment under uncertainty and regulation of new access networks*, Inf. Econ. Policy **26** (2014), 28–41.
32. K. S. Im, K. E. Dow, and V. Grover, *A reexamination of it investment and the market value of the firm an event study methodology*, Inf. Syst. Res. **12** (2001), no. 1, 103–117.
33. A. Sorescu, N. L. Warren, and L. Ertekin, *Event study methodology in the marketing literature: an overview*, J. Acad. Marketing Sci. **45** (2017), no. 2, 186–207.
34. J. Koh and N. Venkatraman, *Joint venture formations and stock market reactions: an assessment in the information technology sector*, Acad. Manag. J. **34** (1991), no. 4, 869–892.
35. D. H. Austin, *An event-study approach to measuring innovative output: the case of biotechnology*, Am. Econom. Rev. **83** (1993), no. 2, 253–258.

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