Identifying the Mobile Data Traffic Explosion in Korea: Explaining the Unlimited Data Use Plans Introduced into the LTE Ecosystem

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ABSTRACT

Offering unlimited LTE data use plans in Korea seems to run counter to the general belief about the impact of flat rate tariff plans on the current mobile ecosystem. This study attempts to empirically explain this unusual case using mobile traffic data and an event study approach. The results show a clear growth in mobile data traffic in Korea, though perhaps not enough to apply the term "mobile data traffic explosion." Additionally, introducing unlimited data plans artificially boosted the growth in LTE traffic volume. These results imply that there may not have been a mobile data traffic explosion in Korea before April 2014, enabling Korea's mobile carriers to launch unlimited LTE data plans. Thus, policy makers in Korea should thoroughly investigate whether potentially damaging high growth exists and its effect on the mobile ecosystem. Moreover, both the domestic media and the academic community should be cautious about using the term "mobile data traffic explosion" until harmful effects from such high growth in mobile data traffic is identified.

Keywords: mobile data traffic explosion; unlimited data usage plans; event study approach

INTRODUCTION

Mobile data traffic has grown dramatically worldwide since the introduction and diffusion of smartphones. For example, a recent Cisco forecast reported that global mobile data traffic will reach about 24.3 exabytes (EB) per month by 2019, nearly a tenfold increase from 2014 at a compound annual growth rate (CAGR) of 57% from 2014 to 2019 (Cisco, 2015). In Korea, with its developed mobile ecosystems, the total volume of mobile data traffic in March 2015 was about 450 times that in November 2009, when smartphones were introduced in the market. Meanwhile, Korean domestic media and some research institutes have frequently expressed serious concerns about the considerable growth in mobile data traffic, describing it as a "mobile data traffic explosion," and have suggested several ways to resolve the problem with this high growth, such as scaling network capacity with additional network equipment (Osseiran et al., 2014; Lee et al., 2013b), using complementary and innovative network technologies to alleviate congestion and make better use of available network resources (Roh et al., 2014; Aijaz et al., 2013), allocating additional spectrum resources (You et

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al., 2011), and adopting usage-based price plans that limit heavy data use (Lee et al,, 2013b).

However, despite the growing concerns about growing mobile data traffic use, three nationwide Korean mobile carriers launched unlimited data plans for their LTE services in April 2014. These strategies are difficult to understand because similar plans for 3G services were regarded as one of the important reasons behind the unprecedented growth in data traffic volume in the 3G mobile ecosystem (Mcqueen, 2009). The domestic mobile carriers also decided not to introduce flat rate tariffs for their LTE services when this advanced mobile service was introduced in July 2011, though did launch some expensive unlimited plans offered temporarily as one promotion strategy. These plans attracted only 165 thousand subscribers (0.3 percent of total LTE subscribers) in March 2014. However, since three mobile service providers introduced more attractive unlimited data use plans in April 2014, the total number of plan subscribers has increased to about 4.5 million (12.2 percent of total LTE subscribers) in March 2015. These flat-rate subscribers have increased the total volume of mobile data traffic from 2.5 to 58.6 Petabytes (PB) in the first years these plans have been offered.

Table 1. Unlimited data use plans for LTE services in Korea

Provider	Unlimited plans until March 2014	Unlimited plans after April 2014
SK Telecom (1st)	LTE 109*	LTE unlimited 100 LTE unlimited 85 LTE unlimited 80 package
KT (2nd)	4G unlimited 129*	Unlimited 129 Unlimited 97 Unlimited 87 Unlimited 79
LG Uplus (3rd)	LTE unlimited 130* LTE unlimited 110* LTE unlimited 95* LTE ultimate unlimited 124	LTE8 unlimited 89.9 LTE8 unlimited 85 LTE8 unlimited 80

Source: Korean mobile carriers' websites
Note: * represents promotional data plan offered until 31 May (SK Telecom), 31 October (KT), and 30 April (LG Uplus) in 2013.

As the growth in mobile data traffic requires that mobile carriers scale their network capacity and manage traffic congestion, it is becoming clear that unlimited data use plans, which could impose a heavy burden on their networks, may be unsustainable (Bateni et al., 2011; Kramer and Wiewiorra, 2014). Flat rate tariffs for LTE in Korea thus seems to contradict the general belief about data plans in the current mobile ecosystem. Therefore, this study aims to explain this unique case in Korea using mobile traffic data. This attempt could contribute toward understanding Korean mobile carriers' unexplained behavior, which has not yet been addressed.

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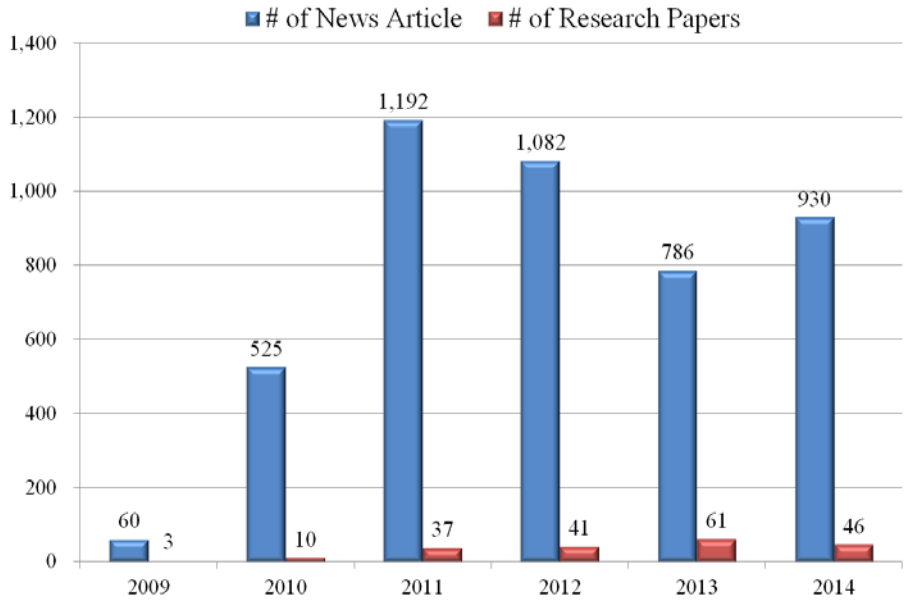
The remainder of this paper is organized as follows. Section 2 provides background into the recent mobile data traffic growth and the effect of unlimited data plans on the phenomena using the related literature. Section 3 analyzes the mobile data traffic in Korea and presents empirical results from the mobile data traffic analysis. Section 4 suggests meaningful implications to explain the mobile service providers' unusual behavior. The final section provides concluding remarks.

THE LINK BETWEEN MOBILE DATA TRAFFIC GROWTH AND UNLIMITED DATA PLANS FOR MOBILE INTERNET CONNECTIONS

Some researchers have used varying expressions to describe the high growth in mobile data traffic, including "mobile data apocalypse" (Dimatteo et al., 2011) and "mobile data tsunami" (Sen et al., 2012). Among them, the term "mobile data traffic explosion" has become dominant expression since smartphones were fully introduced into the mobile ecosystem. For example, in Korea, the media began to use the term frequently from the end of 2009, after Apple's iPhone was introduced in November 2009. Since this expression was widely used by the media for the first time, most domestic (e.g. see Lee and Kim, 2012; Lee et al., 2012) and overseas researchers (e.g., Matinmikko et al, 2013; Sen et al., 2013) also acknowledged the significant growth in global mobile data traffic using this phrase, as shown in Figure 1.

Figure 1. News articles and research papers using the term "mobile data traffic explosion" in Korea from 2009 to 2014



Note: news article numbers drawn from Daum, the second Internet portal in Korea. Research paper numbers drawn from a search result from DBpia, a domestic Korean academic research database.

The media and academic literature offer several reasons behind this growth (Lee et al., 2013b; Mcqueen, 2009; Sen et al., 2012). The first is the introduction of smart mobile devices, such as laptops, tablets, and smartphones, and the rapid increase in their adoption which has significantly boosted both the number of mobile Internet

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connections and the total volume of mobile data traffic. Second, the increase in transmission speeds through mobile network upgrades, such as to Long Term Evolution (LTE) and LTE-Advanced (LTE-A), and improvements in smart devices with large screens, increased battery life, and intuitive user interfaces have contributed to the growth in average data traffic per device. Lastly, the proliferation of traffic-intensive services and applications, particularly the increase in mobile video content with much higher bit rates, has led to a substantial growth in mobile data traffic volume.

Another factor driving the unprecedented growth of mobile data traffic could be unlimited data plans in the mobile ecosystem. In the early stages of the mobile broadband market, e.g., the 3.5G service including HSDPA, flat rate pricing benefitted both consumers and proved lucrative for mobile carriers (Harno, 2010) because consumers were willing to pay a premium for unlimited data use (Altman and Chu, 2001). However, with the tremendous growth in demand for mobile Internet data, mobile service providers faced increased network congestion, though flat rate plans prevented them from earning more from increased data consumption because consumers paid flat rates without considering network costs (Kramer and Wiewiorra, 2014; Dimatteo et al., 2011). Therefore, previous studies suggested flat rate pricing as a factor driving the mobile data traffic explosion (Verkasalo, 2008; Mcqueen, 2009). Most mobile carriers actually experienced problems with network congestion after launching unlimited data plans for their 3G services, and subsequently abandoned their unlimited flat rate plans in favor of volume-based tariffs for their 3G and LTE services (Kramer and Wiewiorra, 2014; Sen et al., 2012). Therefore, one would expect to see fewer carriers offering unlimited data plans for their LTE services (Lee and Kim, 2012; Bateni et al., 2011).

For these reasons, Korean mobile carriers offered unlimited data plans for their 3G services, though did not offer similar plans for their LTE services, save for a few temporary promotions. However, in April 2014, they launched unlimited data plans for their LTE services as shown in Table 1. This decision seems odd because they might represent the first and only unlimited data plans in the global LTE mobile ecosystem. In addition, as the mobile data traffic explosion phenomenon already exists in Korea, carriers could easily forecast that flat rate tariffs for LTE services could create future network congestion problems. Although these plans could be understood as an unavoidable strategy to deal with fierce competition in the mobile market, academic research would benefit from a full understanding of Korean mobile carriers' unique behaviors.

EMPIRIAL ANALYSES AND FINDINGS

This study attempts to find some meaningful reasons behind the appearance of unlimited data plans for LTE services in Korea by examining mobile traffic data. The Korean regulator, the Ministry of Science, ICT and Future Planning has published mobile traffic data monthly since January 2012. Analyzing the data published between January 2012 and April 2015, this paper aims to explain the mobile data traffic explosion in Korea.

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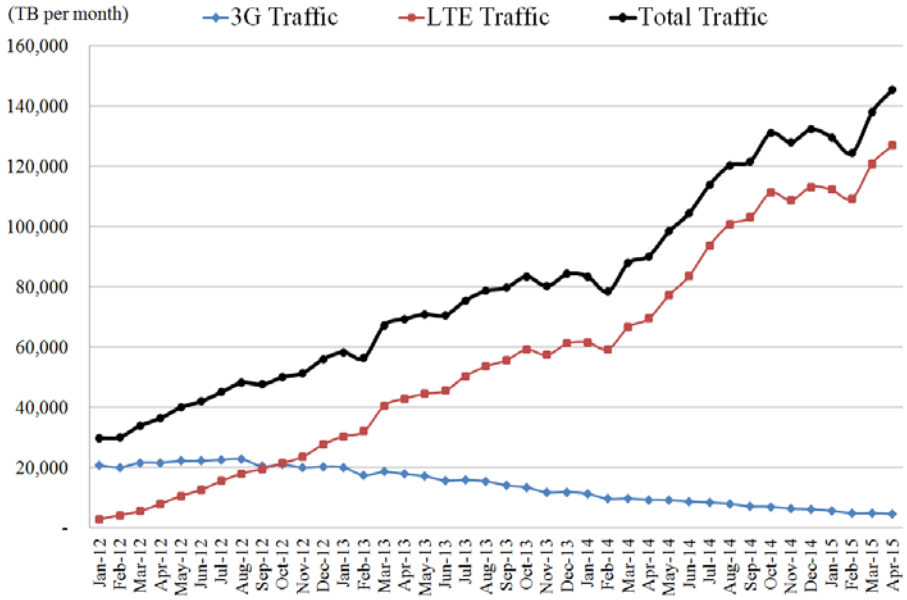
First, this paper examines the trend in the volume of 3G, LTE, and total mobile data traffic from January 2012 to April 2015, as shown in Figure 2. The figure shows that the total mobile data traffic volume increased sharply from 29.7 to 145.5 PB for about the last three years, demonstrating the significant growth in mobile data traffic in Korea. As the actual mobile data traffic grows at a CAGR of 63.4% during the period, the term "mobile data traffic explosion" might be an appropriate expression for the trend of total traffic. The figure also shows the fast transition from 3G to LTE services in the Korean mobile ecosystem. While the total 3G traffic volume decreases from 20.7 to 4.6 PB, the total LTE traffic sharply simultaneously increases from 2.8 to 127.0 PB. Considering that the total volume of LTE traffic is about 87% of the total traffic, with only about 66% of the total mobile subscribers in Korea subscribing to LTE services in April 2015, the mobile traffic explosion seems to exist in the Korean LTE mobile ecosystem.

Figure 2. Mobile data traffic volume trends in Korea



Source: Ministry of Science, ICT and Future Planning (http://www.msip.go.kr)

However, the figure also provides evidence that refutes the existence of the mobile data traffic explosion. First, the last three years show occasional decreases in both the LTE and total traffic. While the unexpected drops in traffic could be caused by seasonal effects, these frequent events may differ from general expectations for the mobile data traffic explosion. Second, the growth rate in the LTE and total traffic gradually decreased during the observation period. Table 2 shows that the compound monthly growth rates (CMGR) for the volume of the LTE and total traffic declined until the end of 2013, then appear to stabilize in 2014. This implies that the term "mobile data traffic explosion" may not appropriately reflect the trend in Korea.

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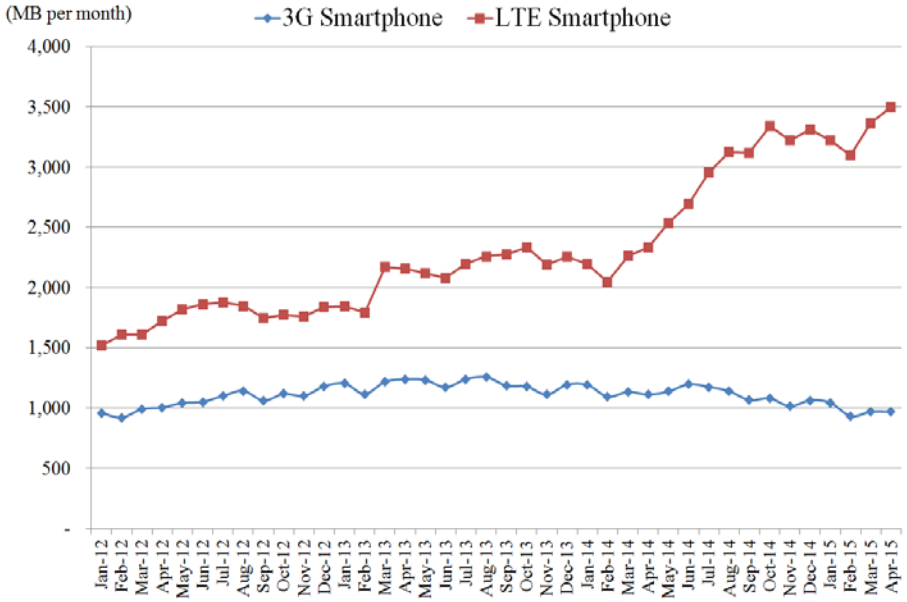
Table 2. Compound monthly growth rate in LTE and total traffic in Korea

Period	First half of 2012	Second half of 2012	First half of 2013	Second half of 2013	First half of 2014	Second half of 2014
Growth rate (Total)	7.1%	4.9%	3.9%	3.0%	3.6%	4.0%
Growth rate (LTE)	34.%	14.1%	8.6%	5.1%	5.3%	5.2%

These observations could suggest cast doubt as to whether the growth in mobile data traffic in Korea is excessively high enough to use the term "mobile data traffic explosion." In addition, as mentioned in previous studies (Verkasalo, 2008; Mcqueen, 2009), introducing unlimited data plans for LTE services could have boosted the volume of mobile data traffic. For example, as shown in Figure 3, the LTE traffic volume per person increased from 1,515 to 2,263 megabytes (MB) at a CMGR of 1.6% from January 2012 to March 2014, though after launching flat rate tariffs for LTE services, from April 2014 to April 2015, it increased from 2,263 to 3,495 MB at a CMGR of 3.4%. This could imply that with unlimited data pricing consumers tend to generate more mobile data traffic by increasing the number of mobile Internet connections and using more traffic-intensive applications, particularly mobile video content.

Figure 3. Trends in mobile data traffic volume per person in Korea



Source: Ministry of Science, ICT and Future Planning (http://www.msip.go.kr)

This study therefore hypothesizes that the introduction of unlimited data plans for LTE services artificially generated more mobile data traffic than before, meaning that the flat rate plans induced the mobile data traffic explosion phenomena in Korea. To examine this hypothesis, this study empirically examines the effect of introducing unlimited data plans for LTE services on the total volume of LTE traffic in using the event study concept. The event study methodology has been used widely in management research (Wilcox et al., 2001) because it provides researchers with a powerful tool to assess the

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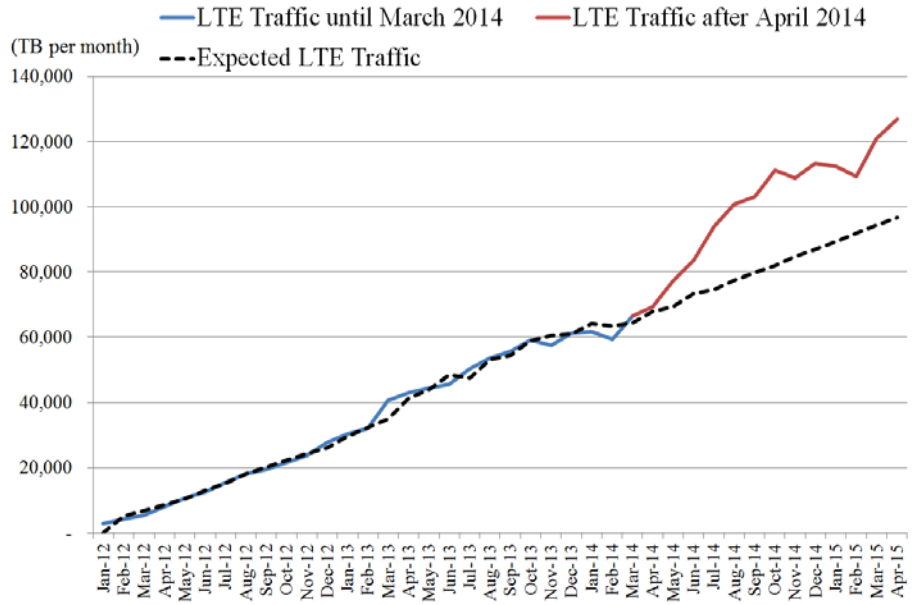
links between a specific event, such as managerial decisions and actions, and the resulting value created by the event (Lee et al., 2013a). Considering that researchers typical use the event study methodology to measure the impact of a specific event on a firm's market value (Rheaume and Bhabra, 2008), it is potentially difficult to apply an empirical method using only monthly mobile traffic data. However, this study borrows the event study approach concept to as it is widely used to evaluate the economic effects of classes of phenomena that would otherwise be hard to measure (MacKinlay, 1997).

Based on the event study concept, this study considers the introduction of unlimited data plans for the LTE services as a specific event, and estimates an expected mobile data traffic trend line without the effect of flat rate tariffs using the actual LTE traffic data from January 2012 to March 2014. Considering that the traffic data is in a time-series form, the optimal forecast model for LTE traffic could be chosen among several time-series models in the form of an autoregressive integrated moving average (ARIMA) model, according to the significance of estimated model parameters and some statistics measuring the models' goodness of fit. This study then finds the most appropriate time-series model, choosing the ARIMA (2,1,1) model satisfying the outlined conditions as much as possible using SPSS 17.0, a popular statistical analysis software package. The dotted line in Figure 4 presents the expected volume of LTE traffic during the observation period, and clearly shows a significant difference between the estimated and actual LTE traffic after April 2014. The estimation indicates that the LTE traffic volume could have been about 97 PB in April 2015 without the unlimited LTE data plans introduced in April 2014. As the actual LTE traffic in April 2015 was about 127 PB, the results imply that about 24% of all LTE traffic may have been a result of the flat rate tariffs, supporting this study's hypothesis.

Figure 4. Expected and Actual LTE traffic trends in Korea



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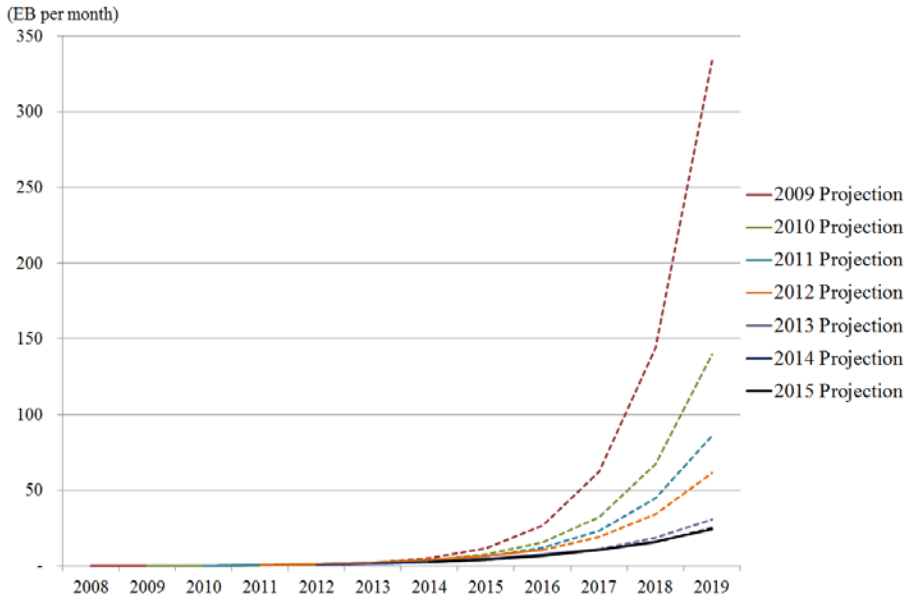
DISCUSSION

This study examined mobile data traffic trends in Korea to discover why Korea's mobile carriers launched unlimited data usage plans for their LTE services in April 2014. The current figure implies that the growth in mobile data traffic volume in Korea is clear, though might not be excessively high enough to use the term "mobile data traffic explosion," as indicated by the frequent dips in traffic and the stabilized growth rate. This study also empirically confirmed that the introduction of flat rate data plans artificially contributed to the increase in the total LTE traffic volume, consistent with findings from previous studies (Verkasalo, 2008; Mcqueen, 2009), using an event study approach.

These results may suggest that it is necessary to reevaluate the mobile data traffic explosion phenomena, at least in Korea. For example, contrary to concerns about the growth in mobile data traffic expressed in domestic media, there is research that calls into question whether a serious situation will actually occur. Figure 5 illustrates a lowered forecast for annual global mobile traffic volume, implying that current forecasts may be overestimated. Cisco's estimated CAGR for the last seven years has also decreased from 131.2% to 57.3%, and tended toward a gradual stabilization, supporting the opinion that the term "mobile data traffic explosion" may not be appropriate. Therefore, the current growth in mobile data traffic in Korea and its effect on the mobile ecosystem should be comprehensively investigated. Both the domestic media and the academic community should be cautious about using this term until the actual harm from the high growth in mobile data traffic is identified.

Figure 5. Global mobile data traffic forecasts



Source: Annual white papers published by Cisco from 2009 to 2015.
Note: The dotted lines present additional estimates assuming traffic growth at the CAGR Cisco calculates annually after the estimated period (5 years).

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On the other hand, this study's results could also explain why the Korean mobile service operators launched unlimited data plans for their LTE services. While these may represent an unavoidable strategy to overcome fierce competition in the Korean mobile ecosystem, the pricing strategy is difficult to implement unless they have some confidence that there is no mobile data traffic explosion or that it is manageable if it exists. The fact that one carrier offered an unlimited data plan, which was promptly followed by the other two service providers could also suggest that they determined that no mobile data traffic explosion existed in Korea, at least before April 2014, and that they have enough network capacity to handle the considerable growth in mobile data traffic for some time.

Another possible answer might surround the acquisition of the 700MHz spectrum band licenses, as Korean mobile carriers could make full use of concerns about potential problems from the explosive growth in mobile data traffic as a reason to gain the licenses. In Korea, spectrum resource assignments are currently fiercely disputed between mobile carriers and broadcasting service providers. As acquiring additional spectrum resources is one of several responses to the explosive traffic growth problem (You et al., 2011; Chetty et al., 2012), mobile service providers could argue that they need the spectrum resources to overcome potential problems from a high growth in mobile data traffic though they already have enough network capacity to manage it. Therefore, Korean policy makers should examine whether the there is in fact an "explosion" in mobile data traffic and its effect on the mobile ecosystem to set spectrum policy.

CONCLUSION

Offering unlimited LTE data use plans in Korea seems to contradict the general belief about the impact of flat rate tariff plans on the current mobile ecosystem. This study attempts to empirically explain this unusual case using mobile traffic data. The results show that the growth in mobile data traffic exists, but may not be as excessively high as to use the term "mobile data traffic explosion." This paper also empirically confirmed that the introduction of unlimited data plans boosted the growth in the total LTE traffic volume using an event study approach. The results imply that such an explosion in mobile data traffic may not have existed in Korea before April 2014, allowing Korea mobile carriers to offer unlimited LTE data plans. Therefore, policy makers in Korea should thoroughly investigate whether this phenomenon actually exists and its effect on the mobile ecosystem. Both the domestic media and the academic community should use the term "mobile data traffic explosion" cautiously until they have identified actual harm from such an increase in mobile data traffic.

While this paper suggested some meaningful implications, the study has limitations. First, by limiting the focus to Korea, the generality of the results should be treated with caution. Therefore, a useful area of future research would extend the analysis to recent mobile traffic data in other countries. Second, the study attempted to empirically examine the negative influence of unlimited data plans in Korea, focusing on identifying the existence of artificial growth in LTE traffic volume. Therefore, further

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research should empirically examine the effect of introducing flat rate data tariffs from other perspectives.

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