Telecommunications Policy 36 (2012) 127–139

Contents lists available at SciVerse ScienceDirect

Telecommunications Policy

URL: www.elsevier.com/locate/telpol

Royalties vs. upfront lump-sum fees in data communication environments

Youngsun Kwon*, Buhm-Kyu Kim

Department of Management Science, KAIST, Daejeon 305-701, South Korea

ARTICLE INFO

Available online 10 December 2011

Keywords:
Spectrum
Auction
Royalty
Lump-sum fee
Economies of scope

ABSTRACT

Mobile communications markets worldwide, today, are saturated, the number of mobile network operators (MNOs) in market is declining, mobile revenues are stagnant or falling, MNOs are becoming wireless Internet service providers, and economies of scope are strengthening. This paper challenges existing dominant views on spectrum assignment and license fee payments, estimates spectrum fees that MNOs would have paid under royalties and then compares them with upfront lump-sum fees actually paid by 3G licensees. This paper further proposes that governments need to consider assigning additional spectrum to incumbents as needs arise without using auctions and adopting royalties as a way of collecting spectrum fees should they collect them.

1. Introduction

As more people adopt smart devices such as smart phones, tablet PCs, and laptops, they use more and more bandwidth-intensive services such as video streaming, cloud computing, and online games, eventually resulting in a rapid increase in data traffic over wireless networks. Currently, smart phones and tablet PCs are driving this rapid increase in data traffic over wireless networks.

Smart phones are more like computers used for checking emails, watching video clips, and listening to music, than phones for voice communications. Therefore, the growth of data traffic over wireless networks parallels that of smart phone users. As shown in Fig. 1, the number of smart phone users has been increasing at rapid rates in OECD countries.[1] To mention a few examples, smart phone users in the UK have increased from 4.6 million at the end of 2007 to 12.8 million at the end of June 2010 (Ofcom, 2010, p. 298), the ratio of smart phone users among cellphone subscribers in the US has increased from 16% to 42% between October 2006 and the end of 2009 (FCC, 2010b, p. 4), and in Korea, the number of smart phone users has already increased more than ten times from about 0.8 million in December 2009 to 10 million in March 2011, and is expected to reach 20 million by the end of 2011 (KCC, 2010).[2]

Another factor of the rapid growth in mobile data traffic is rapidly growing use of mobile video services such as YouTube and CNN news. As shown in Fig. 2, according to Cisco (as cited in OECD, 2010, p. 15), mobile video traffic is expected to grow exponentially; the traffic share of mobile video in total mobile data traffic, which was 39.5% in 2009, is forecasted to increase to 51.4% by 2014.[3]

* Corresponding author. Tel.: +82 42 350 6312; fax: +82 42 350 6339.
E-mail addresses: yokwon@kaist.ac.kr (Y. Kwon), eriol@kaist.ac.kr (B.-K. Kim).

[1] Fig. 1 is photocopied from OECD (2010, p. 14).

[2] KCC stands for Korea Communications Commission. At the end of 2011, the ratio of smart phone users among cellphone subscribers in Korea is expected to grow to 35.7%.

[3] Fig. 2, where TB stands for terabytes, is photocopied from OECD (2010, p. 15).

0308-5961/$ - see front matter © 2011 Elsevier Ltd. All rights reserved.
doi:10.1016/j.telpol.2011.11.017

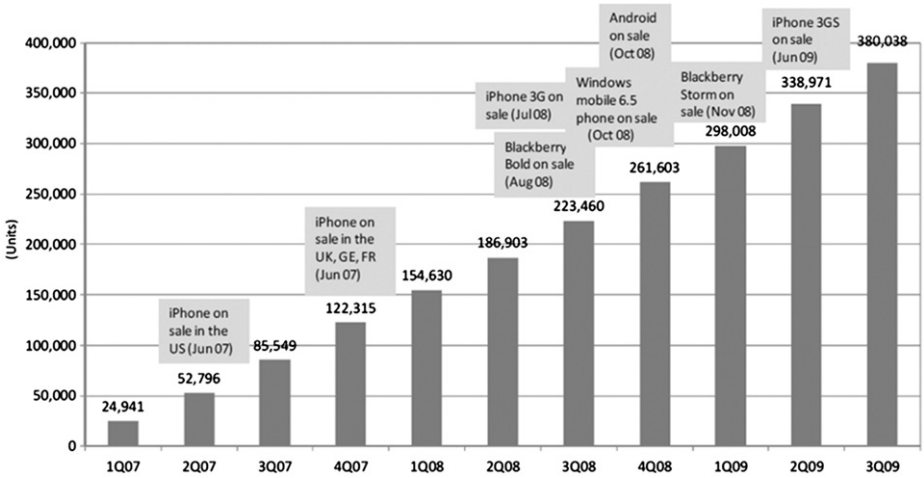

Fig. 1. Worldwide smart phone sales (in thousands of units).

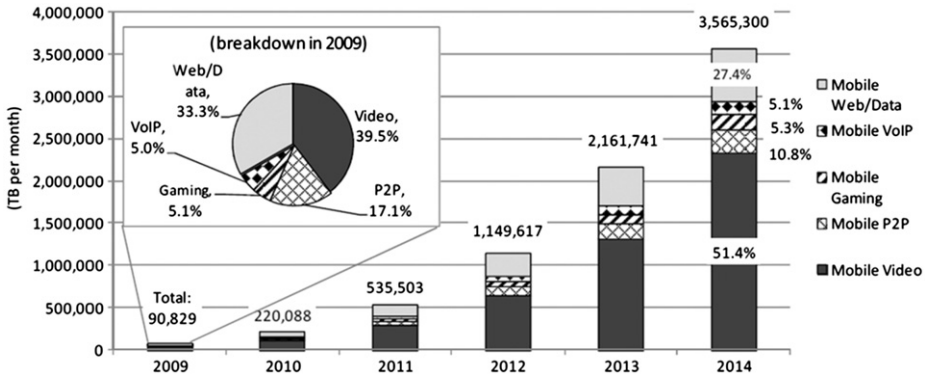

Fig. 2. Mobile data traffic trends.

As a result of increasing smart phone users and heavy use of streaming services, data traffic over wireless networks is skyrocketing in advanced countries. According to the FCC (2010b), world mobile data traffic is expected to grow, on average, to more than 35 times its 2009 levels by 2014. The mobile data traffic of AT&T has grown 5000% over past 3 years (FCC, 2010b). In Korea, the mobile data traffic of three mobile network operators (MNOs) have increased 100–300% since smart phones were introduced in the latter part of 2009. In the UK, mobile data traffic grew 240% between 2008 and 2009 (Ofcom, 2010, p. 283).

In response to this rapid increase in data traffic, governments worldwide have put a policy emphasis on providing more spectrum and encouraging MNOs' investment in faster networks (DCMS & DBIS, 2009; EC, 2010; FCC, 2010a). The FCC (2010a) in the *National Broadband Plan* announced that it would provide 300 MHz bandwidths for wireless broadband by 2015 and additional 200 MHz bandwidths by 2020 and asked the Congress to grant the FCC power to use incentive auctions, which allow incumbent licensees of spectrum bands to obtain a portion of auction proceeds. The UK (DCMS & DBIS, 2009; Ofcom, 2011b) also announced that it would auction the 800 MHz and 2.6 GHz bands for mobile communications services and proposed a policy that would allow the trading of spectrum bands currently being used for 2G and 3G mobile communications services. In addition, the UK (DCMS & DBIS, 2009, p. 15) proposed in the Digital Britain Final Report that it would "make the existing operators' 3G licences indefinite rather than term licences…in order to provide certainty for investment…," which means that spectrum license holders would end up acquiring full property rights over their spectrum. Basically, the ways of coping with increasing data traffic in the US and the UK are to auction additional spectrum, share auction proceeds with spectrum licensees in order to induce licensees to put up their unused spectrum for sale, and allow spectrum trading among MNOs. While the US and the UK were making spectrum assignment process more market friendly, Korea assigned additional spectrum to existing MNOs, 20 MHz each, through a traditional comparative hearing process in 2010 in order to allow them to better manage increasing data traffic over 3G networks.

Exploding data traffic and other factors discussed in the next section pose a few fundamental questions associated with spectrum assignment and license fee payments. For example, spectrum auctions are effective when competition in the market is feasible and the market is growing because new entrants can easily find room for competition. However, as explored in the next section, the wireless communications industry worldwide is becoming increasingly more concentrated and saturated. The objectives of this paper are to present a different view of spectrum assignment and license fee payments, to evaluate whether

3G spectrum fees paid by UK and Korea MNOs were exorbitant, and to discuss the following three questions that arise in the context of today's rapidly changing communication environment: are auctions still a useful means to assign spectrum? are upfront lump-sum payments still a useful way of collecting spectrum fees? and should MNOs pay spectrum fees?

In order to accomplish these objectives, Section 2 points out noteworthy features of the current mobile communications market that can undermine the efficacy of using auctions combined with upfront lump-sum fees. Section 3 provides a brief overview of royalties and upfront lump-sum fees and discusses the assumptions needed to implement numerical analyses for comparisons of spectrum fees under different payment methods. Using data from Korea and the UK, Section 4 calculates the range of spectrum fees that MNOs would have paid under royalties and then compares them with the upfront lump-sum fees actually paid by 3G licensees. Section 5 proposes answers to the three questions raised above and discusses alternatives as well, and Section 6 concludes the paper with a policy suggestion.

2. Noteworthy features of the mobile communications markets

2.1. Saturation and concentration in international mobile markets

Currently, in most advanced countries, mobile markets are saturated and their structure is an oligopoly. In the UK, mobile subscription rates exceeded 100% in 2005 and reached 131.7% in 2009, and four MNOs were then competing in the market (Ofcom, 2010). As of July 1, 2010, two UK MNOs, Orange and T-Mobile, merged to form the UK's biggest MNO, called Everything Everywhere, which, after the merger, had over 27 million subscribers. In Korea, as of the first quarter of 2010, mobile subscription rate exceeded 100% and reached 103.9% at the end of 2010, with three MNOs in existence. According to CTIA, as of the end of 2010, the total number of wireless subscribers in the US is 302.3 million and the wireless penetration rate is 96% of total population.[4] Recently, AT&T announced that it would acquire T-Mobile at the price of $39 billion. This merger, if approved by the government, will enable AT&T to become the largest MNO in the US and reduce the number of nationwide mobile service providers from four to three. In Japan, three MNOs are dominating the mobile service market and the market penetration rate reached 95% as of the end of 2010.[5] In Australia, the mobile penetration rate reached 116% in 2010 and three MNOs are currently competing as Vodafone Australia merged with Hutchison Telecommunications in 2009 (ACMA, 2010; DBCDE, 2009).[6]

These statistics suggest that an additional spectrum auction to meet exploding data traffic would likely be an auction among incumbent MNOs because room for new entrants is almost nil considering mobile market saturation and network roll-out costs. In addition, after the adoption of smart phones, a two year subscription contract is becoming the norm. For example, in the UK, the share of two year contracts among all mobile subscriptions, which was only 13% in the first quarter of 2009, increased to 63% at the end of the second quarter of 2010 (Ofcom, 2010). This implies that customer lock-in on an MNO has strengthened recently and mobile communications markets worldwide have become more rigid. Thus, even though an additional spectrum auction would be open to new entrants, a new entrant is not likely to join the auction.

2.2. Stagnant or falling mobile revenue

MNOs are experiencing stagnant or shrinking mobile revenues while data traffic is exploding. As shown in Fig. 3, the total retail revenue of the UK telecommunication industry as well as mobile revenue fell for the first time in 2009.[7] However, in 2009, the overall data volumes in the UK increased by 68% and mobile data volumes by 240% (Ofcom, 2010, p. 281). As shown in Fig. 4, NTT Docomo (hereafter NTT), the largest MNO in Japan and the first provider of 3G service in the world, has been reporting diminishing revenue since 2007 because of falling voice revenue, even though data revenue is rising and subscribers are increasing moderately. Verizon Wireless and SK Telecom (hereafter Verizon and SKT), the biggest MNOs of the US and Korea, are experiencing sluggish growth in revenue. MNOs' revenue prospects look even bleaker when three major MNOs' ARPU (average revenue per user) trends are examined. As shown in Fig. 5, NTT's ARPU has been declining continuously, SKT's falling since 2007, and Verizon's since 2009. According to Ofcom (2010, p. 316), the voice ARPU of MNOs has been falling steadily from £14.3 in 2004 to £11.1 in 2009.

Given that mobile markets are saturated and revenues are stagnant, additional spectrum to cope with rapidly increasing data traffic is not likely to bring much additional revenue, if any, to MNOs' coffers. Put differently, the fees for additional spectrum to meet increasing data traffic increases the cost of providing wireless communications service without increasing revenue, thereby eventually lowering MNOs' incentive to invest in network upgrades. Even though MNOs are then forced to acquire additional spectrum to meet rising data traffic, their bidding capabilities for additional spectrum are likely to be very confined. If this situation continues, governments worldwide might need to consider collecting license fees not based on the spectrum quantities MNOs use but on actual revenues stemming from the total spectrum quantity used for a wireless communications service.

[4] Data are retrieved from http://www.ctia.org/.

[5] Japan has one more MNO, Willcom, whose market share was about 3% at the end of 2010.

[6] ACMA stands for Australian Communications and Media Authority and DBCDE Department of Broadband, Communications and the Digital Economy.

[7] Raw data for Fig. 3 are from Ofcom (2010, p. 282).

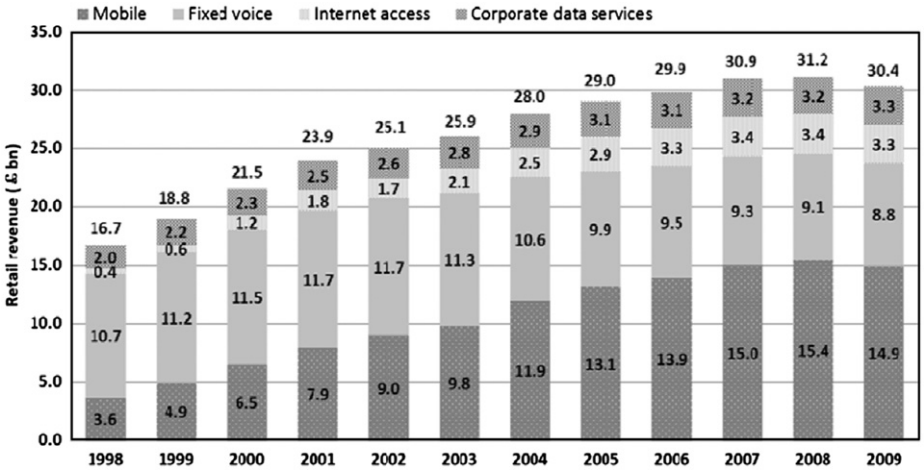

Fig. 3. Revenue composition of the UK telecommunications industry.

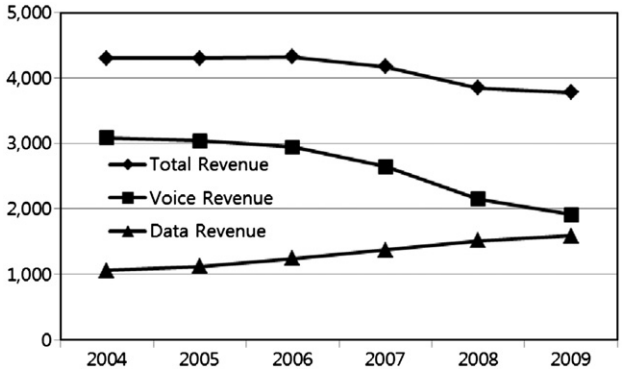

Fig. 4. Changes in NTT Docomo's wireless revenues (unit: billion Yen).

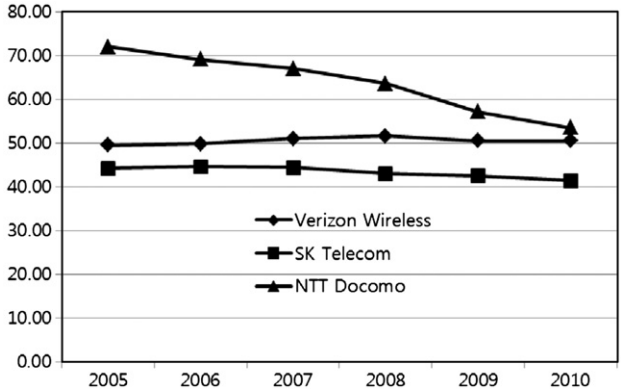

Fig. 5. Recent changes in ARPU since 2005 (units: 100 Yen, $, 1000 Won).

A caveat here is that the statement that additional spectrum to meet increasing data traffic is not likely to increase revenue of MNOs does not mean that additional spectrum does not contribute to overall economic growth. Additional spectrum will enable MNOs to provide faster wireless Internet access, eventually contributing to the growth of content industries such as media, gaming, education, and healthcare.

2.3. Evolution of wireless network service from voice service to connection service

Wireless communications service, which traditionally has been a voice communication service, is turning into a wireless Internet connection service as it evolves from 2G to 3G service. This transition is currently manifest in falling

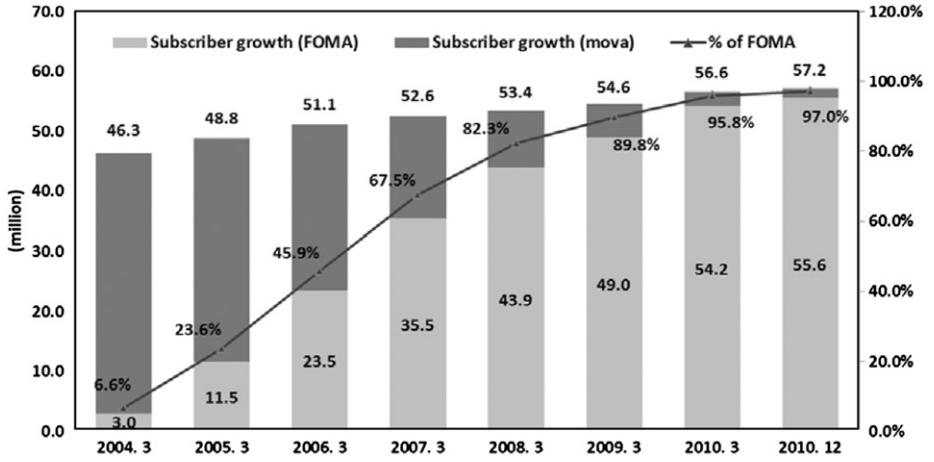

Fig. 6. Changes in NTT Docomo's subscriber mix.

voice revenue and will be intensified as wireless communications service evolves further to 4G service. As wireless communications service progresses to network connection service, mobile VoIP (voice over Internet protocol) is undermining traditional voice call revenue and mobile messenger service similar to Window Live Messenger is replacing the short message service of MNOs.[8]

This transition implies that MNOs' business model is becoming very similar to ISPs' (Internet service providers), whose main revenue source is fixed monthly charges. Under a fixed monthly charge system, market saturation indicates stagnant revenue. Fig. 6 illustrates NTT subscribers' transition process from 2G to 3G, which will be repeated in the future transition process from 3G to 4G, except that there will be no growth in the total number of mobile subscribers.[9] This trend, combined with market saturation, will force the regulators and MNOs worldwide to seriously consider adopting a differential charge system, which would levy different charges for different qualities of wireless connection services. This is because it is apparent that both assigning more spectrum to MNOs and boosting more investment in wireless networks are inevitable in order to let mobile networks evolve into 4G. In short, content providers might have to participate financially in upgrading wireless network capacities, either voluntarily or involuntarily.

Regulators worldwide need to take into account this changing nature of MNOs' business with respect to setting the amount of fees charged for additional spectrum for 3G and 4G. If MNOs turn into wireless ISPs, it might be reasonable for the regulators to charge fees based on actual revenues or not to charge fees at all because spectrum fees, which can be exorbitant, especially when bidding competition is fierce, will simply delay network upgrades and the growth of various content industries. If the regulators insist on charging spectrum fees without adopting a differential charge system for MNOs, MNOs will have two options. The first alternative is to merge with competitors in order to increase network efficiency and to gain cost efficiency by enhancing economies of scale.[10] The 2009 merger between Vodafone and Hutchison in Australia, that of 2010 between Orange and T-Mobile in the UK, and the 2011 merger between AT&T and T-Mobile could also be understood from this perspective and officially noted by Orange and AT&T. The second alternative is to raise the retail prices to shift spectrum fees to subscribers. It has become easier for MNOs to raise retail prices than it was earlier because concentration in the wireless communications market is rising and wireless Internet connection service has become a necessity for more people.

2.4. Intensifying economies of scope: multi-purpose network

Today, all kinds of services, such as media, finance, game, education, and healthcare, are delivered through the wireless Internet. This trend implies that wireless networks have turned into common networks for delivering multi-services and that the effect of economies of scope has become stronger. Bundled subscriptions in the telecommunications market were initially concentrated in the fixed communications market, but are now expanding to the wireless communications market. There are many reasons for bundled subscriptions, as shown in Fig. 7, the main reason being to cut total subscription costs.[11]

As is well-known in industrial organization theories, strong economies of scope can cause the bigger firms to get bigger and the smaller to get smaller. The wireless telecommunications industry, as introduced in Section 2.1, is becoming a more

[8] KakaoTalk (http://www.kakao.com), a downloadable free application for mobile devices, allows users to send and receive messages, individually or collectively. As about a fifth of subscribers have begun to use it as of the end of March, 2010, MNOs and the Korea Communications Commission are carefully monitoring its impact on the MNOs' revenue.

[9] Data of Fig. 6 are retrieved from http://www.nttdocomo.com/about/operating/fomamova.html, where mova represents 2G service and FOMA 3G service.

[10] Refer to Nam, Kwon, Kim, and Lee (2009) for economies of scale in the telecommunications industry.

[11] Data for Fig. 7 are from Ofcom (2010, p. 60).

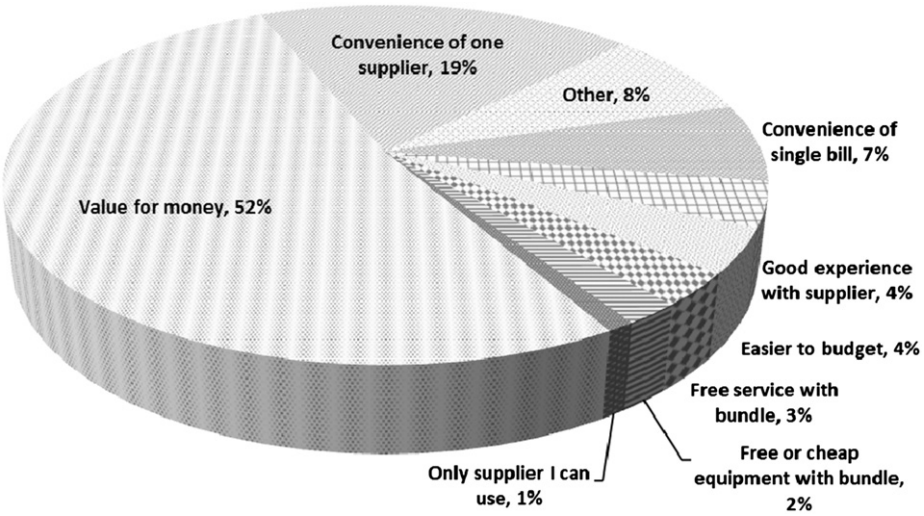

Fig. 7. Reasons for bundled subscriptions of communications services.

concentrated one, which, in turn, directly affects the financial abilities of MNOs. For example, the net income to sales ratio of SKT, whose market share was 50.6% at the end of 2010, was 11.3% in 2010, whereas that of LGU$^+$, whose market share was 17.8%, was 6.6%.[12] Differences in financial abilities will affect MNOs' bidding abilities in auctions for additional spectrum and aggravate unbalanced ownership of spectrum, eventually pushing smaller MNOs further into an unfavorable situation. In other words, spectrum auctions combined with upfront lump-sum fees are likely to intensify a vicious cycle caused by economies of scope, leading to greater market concentration, rather than boosting competition in the market. This point is further discussed in Section 4.

2.5. Changing revenue structure between 2G and 3G

As shown in Fig. 6, just as mobile communications service worldwide is in a transitional phase from 2G to 3G service, so is revenue structure of MNOs. It took about eight years for mobile subscribers to migrate from 2G to 3G in Japan. In the UK, which auctioned five 3G licenses at £22.5 billion in total in 2000, the ratio of 3G subscribers to total mobile subscribers was merely 32% as of the end of 2009. In Korea, MNOs paid 2.6 trillion Won in total for 3G licenses, a half of which was paid in 2001 and the remaining half from 2007 to 2011, but started to offer the service only in 2007. Even though 3G service started late in Korea, its market penetration rate had reached 60.2% at the end of 2010. This means that MNOs in Korea and in other countries had paid either part or the full amount of license fees for 3G service in a transition period, as well as even before they actually started offering it. In short, upfront lump-sum fees do not take into account the changing revenue structures of mobile communications markets.

The basic purpose of assigning spectrum to incumbents or new MNOs is to allow them to use spectrum, a critical input for mobile service, efficiently and in a timely manner, and the governments, and even MNOs, do not know how fast the new mobile service markets will develop. Upfront lump-sum fees can do nothing but increase financial burdens of MNOs, and place full risks intrinsically residing in business as well as caused by government policy mistakes on MNOs, eventually deterring service provision and proliferation of new content services. As explored in Section 3, royalties, notwithstanding their intrinsic problems (Klemperer, 2003), allocate spectrum fees flexibly as the revenue structure of mobile industry changes.

3. Royalties vs. upfront lump-sum fees

3.1. Strengths and weaknesses of payment methods

Two methods for spectrum assignment, which is the process of authorizing communications firms to use a specific spectrum band, have been used worldwide. The most common method of assignment today is an auction that assigns spectrum use rights to the highest bidder; the other is a comparative hearing that determines spectrum users based on pre-announced qualitative and quantitative evaluation criteria. These methods can be combined with either of two spectrum fee payment methods: upfront-lump sum fees or royalties (Klemperer, 2003; Kwon, Lee, & Oh, 2010), but they

[12] LGU$^+$ provides fixed communications services as well as wireless communications services, so its net income to sales ratio cannot be directly compared to SKT's because it is simply a wireless communications service provider. However, in the telecommunications industry in which the economies of scale and scope effects prevail, market share is closely related to net income to sales ratio.

are usually coupled with upfront-lump sum fees, which require the winners to pay the full amount of license fees before service provision starts. There are a few exceptions: Hong Kong uses an auction method whose bids are not dollar amounts but royalty rates (Ure, 2003; Yan, 2004) and Korea uses comparative hearings coupled with a hybrid payment method that is composed of two parts—upfront-lump sum fees and royalties (Kwon et al., 2010).

Kwon et al. (2010) compared royalties with upfront lump-sum fees. They found that royalties generate inefficiencies in product and production factor markets and, as Klemperer (2003) had previously pointed out, MNOs might default on license fees. However, royalty payments also reduce MNOs' investment risks because they allow the governments and MNOs to share the risks. Under a method of upfront lump-sum fees, MNOs shoulder the burden of full risks of investment in wireless network investment because they paid license fees before service begins. Therefore, royalties have a stronger effect on facilitating investment in volatile business environments than do upfront-lump sum fees.

Royalties are becoming a more attractive payment method for spectrum license fees than upfront lump-sum fees because royalties do not raise MNOs' license fees for using additional spectrum when revenues are stable or in decline. The royalty method, as next analyzed in Section 4, also adjusts spectrum fees flexibly between 2G and 3G spectrum during service transition period according to the changing revenue structure.

3.2. Assumptions for the numerical analysis

Spectrum fees (F^u) under upfront lump-sum fees can be written as shown in Eq. (1), where r is the discount rate, i an index for time, E the expectation operator, and n the license period, provided that there is competition among MNOs for a band of spectrum, spectrum is the only fixed input, and all other inputs are competitively provided in the market

$$F^u = \sum_{i=1}^{n} E\left[\frac{Profit_i}{(1+r)^i}\right] \tag{1}$$

According to the bid-rent theory of urban economics, the annual rent for land is the annual expected economic profit that flows every year from a business that uses land, and land price reflects the aggregated present value of expected profits as shown in Eq. (1) when there is competition for land and land is the only fixed input (Kwon, 2002, 2005). This is because in the long run, competition among firms using land as an input for businesses drives up land price until land price soaks up all profits from businesses. The same logic applies to the price of spectrum. If spectrum is only fixed input, the government can garner all the profit from mobile communications service using auctions as long as there is competition for spectrum and the profit expectation is correct. However, if the profit expectation is overrated, MNOs will pay exorbitant spectrum license fees and eventually face economic loss.

F^u is already known in this paper because 3G license fees were determined through competitive auction processes in many countries in 2000. While Austria, Germany, the Netherlands, and the UK used auctions, license fees per capita varied significantly across countries: 103 euros in Austria, 169 euros in the Netherlands, 619 euros in Germany, and 642 euros in the UK (Börgers & Dustmann, 2004). Klemperer (2004) argued that the UK auction was a success because it extracted the greatest fees among other countries that used auctions for assigning 3G licenses.

This paper questions Klemperer's argument because judging whether an auction is a success or not hinges on which criterion is used. This paper computes royalty rates that would have generated the same amount of license fees if the UK had adopted royalties. In addition, in order to see if UK MNOs paid exorbitant fees, the computed royalty rates are compared with the corporate tax rate. With royalties, the present value of spectrum fees (F^r) that the government can collect can be written as shown in Eq. (2). As actual mobile revenue data are available up to 2009 in the UK and 2010 in Korea, revenue data until the end of the license periods must be estimated.[13] Therefore, the magnitudes of the calculated expected royalties depend on three parameters: the future revenue growth rate, the discount rate, and the royalty rate. Sensitivity analyses by changing the parameters are implemented and reported in Appendix A, and the following section reports MNOs' hypothetical royalties, which are calculated with the most plausible parameter values

$$F^r = royalty\ rate \times \sum_{i=1}^{n} \frac{Revenue_i}{(1+r)^i} \tag{2}$$

4. License fees under royalties and upfront lump-sum fees

4.1. The case of Korea: SKT and KT cases

This subsection computes spectrum fees that two Korean MNOs, SKT and KT, would have paid had they paid them under royalties. 40 MHz bandwidth per MNO was assigned for 3G service through a comparative hearing to two MNOs, KT,

[13] UK mobile revenue data for 2010 are partially available from Ofcom. Total mobile revenues except for 3UK's have declined by 3.0% between the 4th quarter of 2009 and that of 2010 (Ofcom, 2011a).

Table 1
3G license fee payments per MNO in Korea (in billion Won, 1$=roughly 1000 Won).

	2001	2007	2008	2009	2010	2011	Total
License fees	**650**	**90**	**110**	**130**	**150**	**170**	**1300**
Interests	**–**	**26.4**	**25.5**	**20.8**	**14.8**	**7.5**	**95**
Total	**650**	**116.4**	**135.5**	**150.8**	**164.8**	**187.5**	**1395**

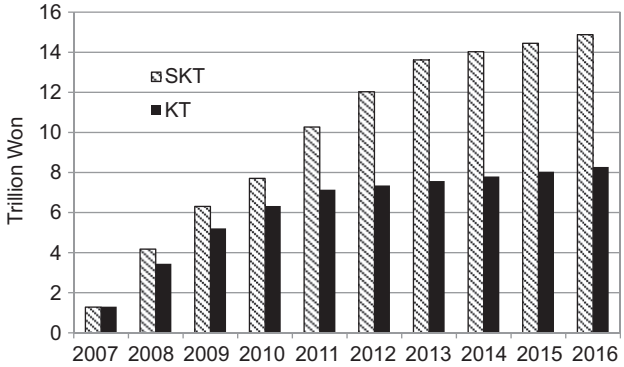

Fig. 8. 3G revenue estimates of SKT and KT.

and SKT, in October 2000.[14] The duration of 3G licenses has been set at 15 years and licenses are in effect until 2016. As shown in Table 1, these two MNOs were obliged to pay 1.3 trillion Korean Won as license fees, a half of which had to be paid in 2001 and the other half, with interest, was allowed to be paid over five years, from 2007 to 2011.[15]

In order to calculate spectrum fees under royalty payments, first, mobile service revenues of KT and SKT are assumed to grow by 3% per year from 2011 to 2016. This assumption is based on the facts that the Korean mobile communications market has matured and that revenue growth is slowing down. The second step in computing spectrum fees is to ascertain the ratios of 3G subscribers to total subscribers in order to sort out 3G revenues from total mobile service revenues. KT's ratio had already reached 91.3% at the end of 2010, and KT is planning to close 2G service in 2011 by inducing the remaining 2G subscribers to move to 3G service.[16] Therefore, KT's ratio need not be assumed, but SKT's does need to be because it was 61.9% at the end of 2010. Considering that smart phone take-up is rapidly growing in Korea, it is assumed that SKT's ratio will reach 80%, 91%, and 100% in the following three years. This scenario of SKT's 3G transition also mimics KT's. The estimated 3G revenue streams of SKT and KT is presented in Fig. 8.[17]

Annual royalties are then obtained by multiplying the royalty rate with estimated 3G revenues, and then discounted by the average market interest rate in order to calculate the present value (PV) of royalties in 2001 value. The royalty rate is assumed to be 3% because the Korean government has announced that it has levied 3% of expected revenue as spectrum fees since 2000.[18] The average three year corporate bond rate 5.8% between 2007 and 2010 is used as a benchmark average market interest (discount) rate, and the discounted annual spectrum fees are next added up, as shown in Table 2. The expected royalties are also calculated by altering the discount rate and revenue growth rate in order to check the sensitivity of royalties to changes in two parameter values; outcomes of the sensitivity analyses are reported in Appendix A.

Three implications can be derived from the comparison between the 1.3 trillion Won that SKT and KT paid in 2001 as 3G spectrum fees and the computed royalties that they would have paid if the Korean government had adopted royalties. To simplify the comparison, it is assumed that 1.3 trillion Won was paid in full without deferred payments as shown in Table 1.

The analysis indicates that KT apparently paid much larger spectrum fees than it should have in 2001, while SKT paid less than it was supposed to pay. According to the benchmark case assuming a 5.8% discount rate, KT seems to have paid about 1.3 times the fees that they would have paid in 2001 if future revenue estimation had been correct. According to the

[14] Another MNO, LGT, also acquired 40 MHz bandwidth for 3G service, but it defaulted on license fees and returned the spectrum band to the government in 2006.
[15] The interest rate for deferred payment was interlocked with the annual yield rate of three year government bonds, and the interest in Table 1 were based on estimated values in 2007.
[16] KT announced in April 2011 that it would provide a rate discount and a handset subsidy to existing 2G subscribers if they move to 3G service.
[17] One caveat is that market shares of SKT and KT are assumed to be stable till 2016.
[18] There is no justification for 3% royalty rate and it is just a policy variable used in Korea.

Table 2
Estimated royalties of KT and SKT in year 2001 value (billion Won).

Discount rates	6.8	5.8	4.8	3.8	2.8	1.8
KT	898.2	996.1	1106.4	1230.9	1371.7	1531.1
SKT	1382.5	1539.2	1716.3	1916.9	2144.4	2402.9

analysis, KT pays less under royalties as long as the discount rate is greater than 3% and SKT pays royalties comparable to upfront lump-sum fees when the discount rate goes up to 6.8%. As more subscribers moved to 3G service, SKT needed additional spectrum, so the KCC assigned 20 MHz bandwidth to SKT in 2010. This time, the KCC used a hybrid license fee payment method: SKT paid 106.4 billion Won as upfront payments and will pay 1.6% of actual revenues every subsequent year adjusted by the ratio of additional spectrum divided by total 3G spectrum that SKT uses and the discount factor, 0.7, to allow for different propagation characteristic of spectrum.

Additional spectrum fees that SKT would pay for additional spectrum are calculated using the same method above. The estimated additional spectrum fees, adjusted to 2001 values, are 209 billion Won when the discount rate is 5.8. Adding this estimate to 1.3 trillion Won amounts to 1.5 trillion Won, which is comparable to the estimated royalties in 2001 value in Table 2. This implies that the upfront lump-sum fees paid by SKT in 2001 met the KCC's target, garnering 3% of future revenues of 3G service as spectrum fees.

It can also be argued, when royalties of Table 2 are considered, that KT actually paid a very lopsided amount of fees in 2001 even though it looks as if the two MNOs paid the same license fees for an equal amount of bandwidth. There are clearly different points of view about whether the license fees were fair. It could be claimed that it was fair for two firms to pay the same amount of fees for using the same amounts of production inputs. However, if MNOs' market shares were considered in determining license fees in 2001, KT's license fees would be quite different. For example, KT's subscribers were 63.2% of SKT's at the end of 2001 and 62.4% at the end of 2010, indicating that their market shares have been stable for the past decade. If the Korean government had assigned 25 MHz bandwidth, about 63.2% of 40 MHz, to KT in 2001 and charged about 821 billion Won 63.2% of 1.3 trillion Won, both MNOs would have paid equal spectrum fees per MHz-subscriber. The spectrum fees of KT and SKT under this scenario are similar to royalties when the discount rate is 6.8 in Table 2. This would have been an acceptable outcome because, in the mobile communications market, the total revenues of MNOs are commensurate with the number of subscribers and so are royalties. If this were the case then, in order to meet increasing 3G subscription, it would have been necessary around 2008 for KT to acquire additional spectrum as SKT obtained an additional 20 MHz bandwidth in 2010. In short, when the government assigns spectrum for 4G service and charges upfront lump-sum fees, it is appropriate to take into account the mobile market structure in order to prevent unbalanced financial burdens on MNOs.

4.2. The case of the UK 3G auction

The UK was the first country that auctioned 3G licenses in the world and it garnered £22.5 billion in 2000.[19] Did the UK MNOs pay exorbitant license fees in 2000? This is still an open question and this subsection tries to answer it by comparing the upfront lump-sum fees with royalties that the UK MNOs would have paid if royalty payments had been used.

In order to estimate royalties that the UK MNOs would have paid under hypothetical royalty payments, past revenue and 3G subscriber data are collected and, based upon such data, future revenues and 3G subscriber shares up to 2021 are extrapolated because 3G licenses are effective for 20 years. It is not possible to gather UK MNOs' individual mobile service revenue data because their holding companies do not provide past revenue data of UK subsidiaries, but, as shown in Fig. 3, Ofcom (2010) provides five UK MNOs' aggregated mobile service revenue data up to 2009. Although aggregated mobile service revenue began to fall in 2009, it is not easy to predict if the declining trend will continue or not because data revenues are rising while voice revenues are falling.[20] Therefore, it is assumed that aggregate MNOs' mobile service revenues of 2009 will continue until 2021. Even though 3G service was introduced in the UK in 2003, the 3G subscription ratio reached only 32% at the end of 2009. Therefore, 3G subscription ratios in the UK are assumed to follow Japan's 3G subscription growth pattern shown in Fig. 6 from 2010, implying that it reaches about 45.9% in 2010 and 100% migration in 2016. 3G revenues in the UK are calculated by multiplying the annual 3G subscription ratio with the actual and predicted aggregated mobile service revenues, and are shown in Fig. 9. To convert calculated annual royalties into year 2001 value, the ten-year average of annual average Sterling certificates of deposit interest rates (3-month), 4.2%, is used.[21]

[19] Retrieved from http://www.ofcom.org.uk/static/archive/spectrumauctions/auction/auction_index.htm.

[20] Ofcom (2011a) reports that mobile revenues have fallen in 2010.

[21] Even though, for the past two years in the UK, the interest rate fell drastically from 5.5% to 0.69%, the past ten year average interest rate is used as the discount rate because uncertainties make it impossible to predict future interest rates until 2021. One percentage point change in interest rate results in £3 billion change in the present value of royalties.

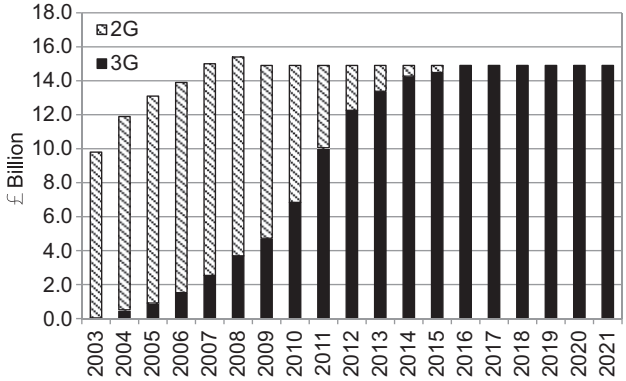

Fig. 9. Mobile service and 3G revenue estimates of the UK.

Table 3
Estimates of UK MNOs' royalties in year 2001 value (£, million).

Royalty rates (%)	2	3	5	10	20
Royalties	1963.0	2944.5	4907.5	9815.0	19,629.9

Table 3 presents estimated royalties that UK MNOs would have paid if the UK had adopted royalty payments in 2001.[22] It is apparent that UK MNOs really paid exorbitant license fees in 2000 because they actually had paid as much in license fees as they would have paid when the royalty rate was more than 20%. When the royalty rate is 22.9%, estimated royalties become comparable to £22.5 billion. As reported in Appendix A, royalty rates that generate £22.5 billion range between 14.1% and 34.1% when revenue growth rates vary between −3% and 3% and discount rates between 2% and 6%. The UK corporate tax rate is 26% of profits (earnings before tax) in 2011, so royalty rates of about 20%, levied on revenue (total sales), must be exceedingly large.[23] It appears that the hypothetical royalty rate of UK MNOs is about seven times higher than that of Korean MNOs notwithstanding the fact that the UK mobile market is about 1.6 times bigger than the Korean market in terms of subscriber numbers. Basically, the exorbitant payments were caused by the MNOs' over expectation of future market growth and the limited supply of 3G spectrum by the governments (Melody, 2001; Ure, 2003).

5. Spectrum assignment and fee payments in data communication environments

5.1. Are auctions still a useful means to assign spectrum?

More than a decade has passed since the first 3G spectrum auction was implemented in the UK. Auctions were supposed to function as a means to increase efficiency in spectrum use and further competition in the mobile communications market. However, as discussed in Section 4, auctions placed on MNOs exorbitant financial burdens, which eventually might have delayed 3G network roll-out and penetration of 3G service in the UK even though this causality has not yet been proven.[24] It should also be noted that exorbitant spectrum fees are not problems endemic only to auctions because, as the case of Korea illustrates, the government using comparative hearings can levy excessive, even if not exorbitant, amounts of spectrum fees in order to garner public funds. It is worth noting that Japan, which did not charge any spectrum fees for 3G licenses, is the first in 3G service penetration rate in the world even though the causality, again, has not been demonstrated.

Spectrum fees themselves do not generate inefficiency in a society as long as they are used efficiently by the governments because they are just income transfers between MNOs and the governments. What matters then is who will use the fund more efficiently: the government or MNOs? No one can definitely answer this question, so, for now, this paper only focuses on the issue of whether auctions are still a useful means to assign spectrum.

The intrinsic merit of auctions is to assign scarce spectrum to those who can use it most efficiently by facilitating competition. Under the current mobile market environments discussed above in Section 2, however, auctions to assign

[22] Royalties are calculated as of 2001 even though MNOs paid license fees in 2000 because, until 2021, licenses are effective for 20 years.

[23] Twenty percent royalty rate implies that firms, whose earnings before tax are 20% of revenues, are paying all their earnings before tax as corporate tax. In the UK, firms actually pay about a quarter of earnings before tax.

[24] Refer to Melody (2001) for the possible factors that caused exorbitant 3G license fees.

additional spectrum to cope with skyrocketing data traffic is very likely to be a competition only among incumbents. Furthermore, if all incumbents need to acquire additional spectrum to accommodate increasing data traffic, the government has to assign additional spectrum to each one of them. Otherwise, some incumbents will not provide mobile communications service to subscribers and they will be forced to go out of business. Therefore, today, the only purpose served by the auction method is to extract spectrum fees. MNOs will have to ponder two choices: acquiring additional spectrum by acquiring a small MNO whose spectrum is underutilized or participating in an auction. Recent M&As in Australia, the UK and the US mobile markets seem to be good examples of this line of reasoning. The first option would appear more attractive to MNOs because M&A brings in spectrum as well as subscribers. In short, in the current mobile market environment the effectiveness of the auction method of spectrum assignment is diminishing.

5.2. Are upfront lump-sum payments still a useful way of collecting spectrum fees?

When bidders are trapped in the winner's curse, they overpay the price, with the 3G UK auctions providing a good example. Royalties, when combined with an auction system, are also not free from the winner's curse. As Klemperer (2003) points out, a royalty auction is not immune from the trap because the royalty rate could be higher than it should be. However, royalties, as Kwon et al. (2010) point out, have the effect of sharing business risks between the governments and MNOs. In other words, under royalties, governments not only garner public funds but also share business risks, whereas they do not share such risks under upfront lump-sum fees. Therefore, if governments are determined to exact license fees, however large the fees may be, royalties are superior to upfront lump-sum fees. It is certain that royalties can increase retail prices and reduce equilibrium quantity traded in the market because royalties are similar to sales taxes. However, it is also true that, in the long-run, the cost of capital caused by upfront lump-sum fees should be recouped. In other words, even though upfront lump-sum fees do not distort market outcomes in the short-run, they have the effect of intensifying economies of scale in the long-run by increasing fixed costs, finally leading, in turn, to reduced competition in the mobile communications market.

There is one more factor that should be considered when a choice between royalties and upfront lump-sum fees is needed. Mobile communications service is evolving from 2G to 3G and will evolve further from 3G to 4G. Under upfront lump-sum fees, MNOs will be manipulative in determining evolution speed. They might try to delay 4G auctions because they have to pay 4G license fees before revenues from 4G service flow into their coffers. However, royalties do not have such a deterring effect because no revenue from new service means no additional royalties for spectrum licenses. In addition, royalties will be flexibly adjusted as subscribers and revenues immigrate from old to new service as shown in Figs. 6 and 9. Royalties are a case of the proportionate spectrum fees and, as Melody (2001) pointed out, can "encourage efficient choices between using 2G and 3G spectrum by all operators" (p. 10). The same will be true of the choices between 3G and 4G spectrum.

5.3. Should MNOs pay spectrum fees?

Japan and Finland have not levied any license fees on MNOs and, as shown in Fig. 6, migration to 3G service from 2G in Japan was almost completed as of the end of 2010. Japan is the first country to have completed 3G service transition. Japan's experience thus casts doubt on the validity of levying license fees.

Spectrum fees have been used as a screening device to sift out inefficient MNOs in both auctions and comparative hearings. In other words, the fees are not only an outcome of the selection process but also a screening device. In the current mobile market environments, the former function has become more apparent, while the latter function is withering away. Moreover, spectrum fees can also skew further mobile market shares, as illustrated in the case of Korean MNOs in which the fees have the effect of treating bigger firms more favorably. Thus, it might not be an exaggeration to say that license fees are nothing but a money spinning tool to raise public funds.

At the present time, only when the government can use public funds accruing from mobile services more efficiently than MNOs, that is, when it creates more wealth with the fees in an economy than do MNOs, spectrum fees can be justified. However, there is no evidence in general that the public sector performs better than the private sector.

It might be argued that, without spectrum fees, MNOs have no incentive to economize on spectrum use. This is a fallacious argument because upfront lump-sum fees and royalties have nothing to do with spectrum use once MNOs acquire certain amounts of spectrum because economizing on spectrum use ex-post facto does not reduce spectrum fees.

In conclusion, mobile networks today are not just phone networks but one of the key infrastructures, on which various new services such as online healthcare, banking, and education services will be traded. Accordingly, it may be better not to charge spectrum fees at all that could possibly deter network upgrades. Even though MNOs do not pay license fees, they pay corporate taxes, so the absence of license fees simply translates into lowering actual corporate taxes.

6. Conclusion

At present, mobile communications markets worldwide are saturated, the number of MNOs in the market is declining, mobile revenues are stagnant or falling, MNOs are becoming wireless ISPs, and economies of scope are strengthening.

Given these volatile environments of the mobile communications market, governments worldwide are facing an important policy issue of how to facilitate continuous evolution of mobile networks and, eventually boost economic growth and job creation by transforming traditional service industries into IT-based service industries.

As discussed in Sections 4 and 5, upfront lump-sum fees can be exorbitant, reducing rather than boosting competition by increasing fixed costs and placing unbalanced fees on MNOs, and deterring a smooth transition of mobile service from 2G to 3G, and then 4G because migration to upgraded network connection service is not likely to increase revenues while it will definitely increase costs. Therefore, in order to effectively address this policy issue, the governments worldwide needs to consider assigning additional spectrum to incumbents as needs arise without using auctions and adopting royalties as a way of collecting spectrum fees should they collect them. This is because collecting spectrum fees in and of itself cannot and should not be the first objective of the governments; rather, the first objective should be promoting content and service industries on the upgraded mobile networks. In addition, it may be better to assign additional spectrum to incumbents without charging fees at all.

History testifies, as has been briefly touched on this paper, that facilitating competition in the telecommunications industry through auctions and divestitures has been a dream rather than a reality. This is why Australia is establishing a monopoly that builds and operates the national broadband network on a wholesale-only open access basis (DBCDE, 2009). It is time to reconsider the validity of facility-based competition in the telecommunications industry.

Acknowledgments

This work was supported by the National Research Foundation of Korea Grant funded by the Korean Government (NRF-2010-327-B00134). We thank two referees for their constructive comments and we are solely responsible for any remaining errors.

Appendix A

Royalty payments, as stated above, depend on revenue growth rates during the remaining time of license periods, discount rates, and royalty rates. Tables A1 and A2 present the results of sensitivity analyses for SKT and KT when revenue growth rates vary between 1% and 6% and discount rates between 3% and 8% under a 3% royalty rate.

In the case of the UK, royalty rates that generate £22.5 billion are calculated by altering revenue growth rates and discount rates. As shown in Table A3, royalty rates range between 14.1% and 34.1% when revenue growth rates vary between −3% and 3% and discount rates between 2% and 6%.

Table A1
Royalty payments: SKT (unit: billion Won).

Revenue growth rates (%)	Discount rates (%)					
	3	4	5	6	7	8
1	1985.5	1777.2	1593.2	1430.6	1286.6	1158.8
2	2040.1	1825.1	1635.5	1467.8	1319.4	1187.8
3	2096.5	1874.7	1679.1	1506.3	1353.4	1217.8
4	2154.8	1926.0	1724.2	1546.0	1388.4	1248.8
5	2215.1	1978.9	1770.7	1587.0	1424.6	1280.8
6	2277.3	2033.6	1818.8	1629.4	1462.0	1313.8

Table A2
Royalty payments: KT (unit: billion Won).

Revenue growth rates (%)	Discount rates (%)					
	3	4	5	6	7	8
1	1279.2	1149.4	1034.5	932.6	842.0	761.4
2	1310.1	1176.6	1058.5	953.7	860.7	777.9
3	1342.1	1204.8	1083.3	975.6	880.0	794.9
4	1375.1	1233.8	1108.8	998.1	899.8	812.5
5	1409.2	1263.8	1135.2	1021.4	920.4	830.7
6	1444.5	1294.8	1162.5	1045.4	941.6	849.4

Table A3
Royalty rates corresponding to £22.5 billion: the UK MNOs (unit: %).

Revenue growth rates (%)	Discount rates (%)				
	2	3	4	5	6
−3	20.4	23.3	26.5	30.1	34.1
−2	19.3	22.0	25.1	28.5	32.3
−1	18.1	20.7	23.7	26.9	30.6
0	17.1	19.5	22.3	25.4	28.9
1	16.0	18.4	21.0	24.0	27.3
2	15.1	17.3	19.8	22.6	25.8
3	14.1	16.3	18.7	21.3	24.4

References

ACMA. (2010). *Communications report 2009–2010*. Retrieved from 〈http://www.acma.gov.au/webwr/_assets/main/lib311995/2009-10_comms_report-complete.pdf〉.

Börgers, T., & Dustmann, C. (2004). Rationalizing the UMTS spectrum bids: The case of the UK auction. In: G. Illing, & U. Klüh (Eds.), *Spectrum auctions and competition in telecommunications* (pp. 119–157). Cambridge, MA: The MIT Press.

DBCDE. (2009). *National broadband network: Regulatory reform for 21st century broadband* [Discussion paper]. Australia: Australian Government. Retrieved from 〈http://www.dbcde.gov.au/broadband/national_broadband_network/regulatory_reform_for_21st_century_broadband〉.

DCMS, & DBIS. (2009). *Digital Britain final report*. UK: Department for Culture, Media and Sport and Department for Business Innovation & Skill. Retrieved from 〈http://www.official-documents.gov.uk/document/cm76/7650/7650.pdf〉.

EC. (2010). *A digital agenda for Europe*. COM(2010) 245 final. Retrieved from 〈http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2010:0245:FIN:EN:PDF〉.

FCC. (2010a). *Connecting America: The national broadband plan*. Retrieved from 〈http://www.broadband.gov/download-plan/〉.

FCC. (2010b). *Mobile broadband: The benefits of additional spectrum* [OBI Technical Paper Series No. 6]. Retrieved from 〈http://transition.fcc.gov/Daily_Releases/Daily_Business/2010/db1021/DOC-302324A1.pdf〉.

KCC. (2010). *스마트 모바일 시큐리티 종합계획* [Smart mobile security plan]. Seoul, Korea: KCC. Retrieved from 〈http://www.kcc.go.kr/user.do?mode=view&page=P05020000&dc=K05020000&boardId=1041&boardSeq=30871〉.

Klemperer, P. (2003). *Auctions: Theory and practice*. Princeton, NJ: Princeton University Press.

Klemperer, P. (2004). Some observations on the British 3G telecom auction: Comments on Börgers and Dustmann. In: G. Illing, & U. Klüh (Eds.), *Spectrum auctions and competition in telecommunications* (pp. 163–169). Cambridge, MA: The MIT Press.

Kwon, Y. (2002). Rent-commuting cost function versus rent-distance function. *Journal of Regional Science*, *42*, 773–791.

Kwon, Y. (2005). Urban comparative statics when commuting cost depends on income. *Journal of Housing Economics*, *14*, 48–56.

Kwon, Y., Lee, J., & Oh, Y. (2010). Economic and policy implications of spectrum license fee payment methods. *Telecommunications Policy*, *34*, 175–184.

Melody, W. H. (2001). Spectrum auctions and efficient resource allocation: Learning from the 3G experience in Europe. *Info*, *3*, 5–10.

Nam, C., Kwon, Y., Kim, S., & Lee, H. (2009). Estimating scale economies of the wireless telecommunications industry using EVA data. *Telecommunications Policy*, *33*, 29–40.

OECD. (2010). *Mobile communication developments in the OECD area*. Paris, France: Organization for Economic Cooperation and Development. DSTI/ICCP/CISP(2010)3/Final. Retrieved from 〈http://www.oecd.org/dataoecd/22/59/48459973.pdf〉.

Ofcom. (2010). *Communications market report*. Retrieved from 〈http://stakeholders.ofcom.org.uk/market-data-research/market-data/communications-market-reports/cmr10/〉.

Ofcom. (2011a). *Telecommunications market data tables: Q4 2010*. Retrieved from 〈http://stakeholders.ofcom.org.uk/binaries/research/cmr/Q4_2010.pdf〉.

Ofcom. (2011b). *Notice of proposals to make 900 MHz, 1800 MHz and 2100 MHz public wireless licenses tradable*. Retrieved from 〈http://stakeholders.ofcom.org.uk/binaries/consultations/trading-900-1800-2100/summary/900-1800-2100.pdf〉.

Ure, J. (2003). Deconstructing 3G and reconstructing telecoms. *Telecommunications Policy*, *27*, 187–206.

Yan, X. (2004). 3G licensing in Hong Kong: The debate. *Telecommunications Policy*, *28*, 213–226.