Determination of the Optimal Access Charge for the Mobile Virtual Network Operator System

Byung Woon Kim and Sung Uk Park

ABSTRACT—The introduction of a mobile virtual network operator (MVNO) system is expected to increase consumer benefits, boost competition in the mobile market, utilize idle bandwidth, and expedite mobile-fixed line convergence and growth in the mobile Internet market. This research endeavors to study the optimal access charge for an MVNO system, which is expected to be introduced to the Korean mobile communications market. We found that the optimal access charge is higher in the interdependent model than in the independent model if demand for mobile phone service is based on a substitution relationship. We also found that the optimal access charge is higher than the marginal cost.

Keywords—MVNO, interconnection, access charge, service-based competition, facilities-based competition.

I. Introduction

The Ministry of Information and Communication of Korea disclosed on July 25, 2003 that it would pursue service-based rather than facilities-based competition to boost the competition of the communications market. The ministry noted that fixed-line carriers such as KT, Hanaro Telecom, DACOM, and Onse Telecom should introduce a mobile virtual network operator (MVNO) system in the mobile communications market to encourage fair competition among carriers and to expand consumer benefits [1].

ITU defined an MVNO as a carrier providing users with mobile services without its own airtime and government-issued licenses [2]. UK's Ofcom defined it as "an organization providing customers with mobile phone services without owning any airtime [3]. It offers a relatively wide range of definitions under the premise that various forms of an MVNO

exist on mobile network operator (MNO) facilities and network systems [4].

Specifically, OVUM defined an MVNO as a carrier a) providing customers with a mobile service, b) having an independent mobile network code (business registration number recorded on the SIM card), c) issuing independent SIM cards, d) directly operating a mobile communications switch including a home location register, and e) without its own airtime [5]. The Ministry of Internal Affairs and Communications of Japan defined an MVNO as a telecommunications service provider offering mobile communications services without opening a radio station [6]. On the other hand, OFTA of Hong Kong defined an MVNO as the provider of mobile communications services to customers by mutually connecting to the MNO's radio communication infrastructure [7]. Such definitions indicate that an MVNO has not been consistently defined to date [2].

Based on the definitions of an MVNO given by the Ministry of Internal Affairs and Communications, OFTA, and Ofcom, an MVNO can be classified into service provider (SP)-MVNO (or resale-type MVNO), enhanced service provider (ESP)-MVNO (or lite-MVNO), and full-MVNO models. First, the SP-MVNO model pertains to a carrier purchasing airtime at a wholesale price from mobile communications service providers for resale to consumers. Second, the ESP-MVNO model refers to a carrier pursuing its own strategies and providing additional services through its own service platform while using the mobile network code and SIM card of mobile network operators, although the carrier entirely relies on mobile network operators for voice services [5]. Third, the full-MVNO model is a carrier borrowing irreplaceable mobile communications infrastructures such as the base stations, base station controllers, and radio transmissions from mobile

communications service providers and providing corresponding services after taking into account the replaceable infrastructures owned by the carrier such as subscriber management, SIM card[1], mobile switching center, home location register, and marketing. In addition, the carrier can distinguish and manage all telephones using a mobile network code and its own intelligent network [9]-[10].
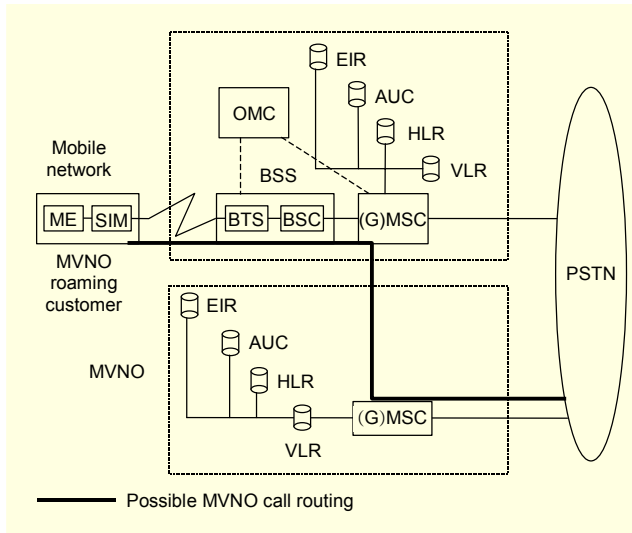

Fig. 1. MVNO model.

II. The Model

The model used here assumes that an existing carrier is a monopoly in the upstream market and that the existing and new companies (full-MVNO) will compete in the downstream market. The basic independent model for the quantitative analysis is based on the Leite model [11] and the Laffont & Tirole model [12]. It assumes a constant return to scale and does not consider a fixed cost of entry. In this paper, we apply and expand the independent models used. In this case, we assume ($p_1(q_1, q_2), p_2(q_1, q_2)$), and the profits for existing companies and new entrants are as follows.

$$\Pi^I = p_1 q_1^I + p_2 q_2^I + \alpha q_2^{MVNO} - c_1(q_1^I + q_2^I + q_2^{MVNO}) - c_2 q^I$$

$$\Pi^{MVNO} = p_2 q_2^{MVNO} - \alpha q_2^{MVNO} - c_2 q_2^{MVNO}$$

In the above profit equation of existing companies, Π^I, $p_1 q_1^I$ is the income of the upstream market, $p_2 q_2^I$ is the income of the downstream market, αq_2^{MVNO} is the access

charges [12] paid by new entrants, $c_1(q_1^I + q_2^I + q_2^{MVNO})$ is the cost incurred by the upstream market, and $c_2 q_2^I$ is the cost incurred by the downstream market. In the second equation, Π^{MVNO} new entrant MVNO profits, $p_2 q_2^{MVNO}$ is the income of the downstream market, αq_2^{MVNO} is the access charges [13] disbursed to existing companies, and $c_2 q_2^{MVNO}$ is the cost incurred by the downstream market. The conditions are as follows.

$$\frac{\partial \Pi^I}{\partial q_1^I} = p_1 + p_1^1 q_1^I + p_2^1 q_2^I - c_1 = 0 \tag{1}$$

$$\frac{\partial \Pi^I}{\partial q_2^I} = p_1^2 q_1^I + p_2 + p_2^2 q_2^I - c_1 - c_2 = 0 \tag{2}$$

$$\frac{\partial \Pi^{MVNO}}{\partial q_2^{MVNO}} = p_2 + p_2^2 q_2^{MVNO} - \alpha - c_2 = 0 \tag{3}$$

We denote the solutions of (1) to (3) as $\hat{q}_1^*$ and $\hat{q}_2^*$.

1. The First-Best Results for the Downstream Market

In the case of independent demand, the maximization of the social welfare variable W is the desired target.

$$\text{Max} \quad W = V(p_1(q_1, q_2), p_2(q_1, q_2)) + \Pi^I + \Pi^{MVNO}$$

where, q_2 is the target variable that maximizes W, and it is obtained as follows:

$$\frac{\partial W}{\partial q_2} = p_2 - c_1 - c_2 = 0. \tag{4}$$

From (4), we can derive $\hat{p}_2 = c_1 + c_2$.

The values derived from (1) and (4) are expressed as $\hat{q}_1^F$ and $\hat{q}_2^F$.

Similar to the case of independent demand, marginal cost pricing is realized where consumer and producer surpluses are maximized.

To determine the first-best access charge for the downstream market, the profit maximization conditions (2) and (3) are applied. Consequently,

$$\hat{\alpha}^F = c_1 + \frac{c_1 + c_2}{\eta_2} + \frac{\partial p_1}{\partial p_2} \hat{q}_1^F.$$

A comparison can be made between the independent demand case[2] and the interdependent demand case.

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[1] There is no SIM card in a cellular Code Division Multiple Access system [8].

[2] A comparison of the optimum access charge levels between the independent and interdependent models is possible because $q_2^F = \hat{q}_2^F$.

In case of independent demand, the first-best access charge is denoted by α^F, which is summarized in Table 1. In substitutional relationship, where $p_1^2 \geq 0$, $\hat{\alpha}^F \geq \alpha^F$; in complementary relationship, where $p_1^2 < 0$, $\hat{\alpha}^F < \alpha^F < c_1$. There is also a possibility that $\hat{\alpha}^F > c_1$ in substitutional relationship and $\hat{\alpha}^F < c_1$ in complementary relationship.

2. The Second-Best Result for the Downstream Market

An analysis can be made using the viable firm Ramsey optimum (VFRO), which assumes a company's profit is over 0, or using the viable industry Ramsey optimum (VIRO), which assumes an industry's profit is over 0. As the VFRO has more stringent conditions compared to the VIRO, we will apply the VIRO. If we express it in the form of a Lagrange formula, it is as follows:

$$\text{Max} \quad L = V + (1+\lambda)(\Pi^I + \Pi^{MVNO}) .$$

The optimum q_2 value is such that

$$\partial L \big/ \partial q_2 = 0 . \tag{5}$$

The solution derived from (1) and (4) is expressed as $\hat{q}_1^S$ and $\hat{q}_2^S$. Then, (5) is applied:

$$\frac{\hat{p}_2^S - c_1 - c_2}{\hat{p}_2^S} = -\frac{\lambda}{1+\lambda}\left(\frac{1}{\eta_2} + \frac{1}{\eta_{12}}\frac{\hat{q}_1^S}{\hat{q}_2^S}\frac{\hat{p}_1^S}{\hat{p}_2^S}\right) .$$

The above result is the second-best result value based on corporate profits. If $\lambda = 0$ it becomes the first-best value, which means that the condition is insignificant.

Combining (2) and (3) results in $\hat{\alpha}^S = \frac{1-\lambda}{1+\lambda}\left(\frac{c_1+c_2}{\eta_2} + p_1^2\hat{q}_1^S\right) + c_1$. In case of independent demand, the second-best access charge is denoted by α^S, which is summarized in Table 1. in substitutional relationship, where $p_1^2 \geq 0$, $\hat{\alpha}^S \geq c_1$ and $\hat{\alpha}^S < c_1$; in complementary relationship, where $p_1^2 < 0$, $\hat{\alpha}^S < c_1$.

In any case, if the relationship is of the substitution basis there is a possibility that $a > c_1$. This applies only if market q_1 is relatively larger than market q_2, which can be translated into a case where the quantity of the upstream market is larger than the aggregate quantity of the downstream market. However, if the two markets are similar in size $(q_1 \approx q_2)$, and if they have a complementary relationship, $\left|p_1^2\right| < \left|p_2^2\right|$, then $\hat{\alpha}^S < c_1$. So, the results from the above economic model can be summarized in Table 1 in the following way.

Table 1. Relation between demand type and access charge.

	First-best solution	Second-best solution
Independent	$\alpha^F = c_1 + \dfrac{c_1+c_2}{\eta_2} < c_1$	$\alpha^S = (\dfrac{1-\lambda}{1+\lambda})(\dfrac{c_1+c_2}{\eta+\lambda}) + c_1 < c_1$
Interdependent	$\hat{\alpha}^F = c_1 + \dfrac{c_1+c_2}{\eta_2} + \dfrac{\partial p_1}{\partial p_2}\hat{q}_1^F$	$\hat{\alpha}^S = \dfrac{1-\lambda}{1+\lambda}(\dfrac{c_1+c_2}{\eta_2} + p_1^2\hat{q}_1^S) + c_1$
Substitutional	$\hat{\alpha}^F \geq \alpha^F, \ \hat{\alpha}^F < c_1$	$\hat{\alpha}^S \geq c_1, \ \hat{\alpha}^S < c_1$
Complementary	$\hat{\alpha}^F < \alpha^F < c_1$	$\hat{\alpha}^S < c_1$

III. Conclusion

In order to encourage service-based competition of the mobile telephone market, Korea's communications regulatory authority, the Ministry of Information & Communication, is considering launching an MVNO system, which will allow the mobile telephone services to use bandwidth for existing mobile carriers.

In this research paper, we provide a study on how an access charge can be determined with the introduction of an MVNO system by assuming whether demand can be both independent and interdependent. For an interdependent model, the access charges are different between the two cases where two goods are on the substitution or complementary relationship.

Through a detailed analysis, we find that the optimal access charge is higher for the interdependent model than for the independent model; if the demand for the mobile phone is a substitution-based relationship, the optimal access charge is higher than the marginal cost. However, if the relationship is complementary, the access charge is lower than the marginal cost in the upstream market.

Therefore, if an MVNO system is introduced, there will be disputes with existing carriers with regard to network and bandwidth usage. Thus, it is necessary to first confirm if the relationship is substitution- or complementary-based, which should be reflected on the policy of determining the access charge.

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