MEASURING ECONOMIES OF SCALE AND SCOPE IN THE TELECOMMUNICATIONS INDUSTRY

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ABSTRACT
This paper proposes the concept of superadditive profit function, which can lead to diversification of business portfolio by firms. The superadditive profit function concept includes economies of scope as well as superadditive revenue function. This paper explores bundled consumption of telecommunication services and illustrates the impact of growing data traffic on the economies of scale in the telecommunications industry by using a firm’s data. In order to illustrate average cost curves, pseudo subscriber number concept is proposed and used in this paper. Growing data traffic does not seem to have increased cost of capital significantly for the past few years in Korea.

KEYWORDS: Economies of Scope; Profit Function; Subadditivity; Superadditivity; Bundling

1. INTRODUCTION

Today, it is the norm rather than the exception that telecommunication firms seek aggressively economies of scope in production and bundling strategy in sales as wireless and wired networks have turned into common networks for delivering a multitude of services such as media, finance, game, education, and healthcare. Telecommunication firms, once provided only voice service in the past, are now offering multiple services, including short message service (SMS), media, and Internet connection service. Fixed network operators (FNOs) such as AT&T, BT, and KT provide voice connection, Internet connection, and IPTV. In a similar vein, mobile network operators (MNOs) such as Verizon, Orange, and SK Telecom (hereafter SKT) provide voice connection, SMS, digital media broadcasting (DMB), and Internet connection. Furthermore, as FNOs and MNOs merge to share core and transmission networks and distribution channels, the distinction between them is weakening and network operators (NOs) are evolving into comprehensive communications service providers.

This business diversification trend observed in the telecommunications industry seems to be beneficial to customers as well. According to Ofcom (2010), there are many reasons for bundled subscription, as shown in Fig. 1, the main reason being to cut total subscription costs.2

Noting this trend of the telecommunications industry, this paper first proposes a theoretical framework to explain NOs’ business diversification behavior in a broader context, combining demand and supply sides. In economics literature, firms’ business
diversification strategies have been separately studied from either revenue or cost perspective. For example, bundling (or tie-in) can be seen as a theory to explain firms' diversification behavior in terms of demand, while economies of scope and the subadditivity of cost functions are those to explain it in terms of supply. Up until now, there has been no attempt to propose a theory that integrates both revenue and cost sides of firms in order to explore firms' incentive to diversify their business portfolios. This paper uses profit function to elucidate economies of diversification simply because profit function has both revenue and cost information, allowing us to understand economies of diversification in a broader perspective.

Figure 1 REASONS FOR BUNDLED SUBSCRIPTIONS OF COMMUNICATIONS SERVICES

Second, this paper discusses the issues associated with measuring economies of scope and scale in the telecommunications industry and then tries to measure economies of scale using a Korean mobile firm's cost data.

The structure of this paper is as follows. Section 2 introduces a theory focusing on profit function to explain economies of diversification and discusses the merits of the theory. Section 3 explores bundled consumption of telecommunication services and section 4 discusses output measurement issues and roughly estimates economies of scale using SKT's data. Section 5 concludes the paper.

2. ECONOMIES OF DIVERSIFICATION

2.1 DEFINITION

Traditionally, economies of diversification have meant efficiency gains from a firm’s joint production and are often used interchangeably with economies of scope (Prior & Sola, 2000; Teece, 1980). In addition, economies of scope, meaning cost efficiency caused by joint production, are more frequently used than economies of diversification in the
theories of industrial organization. In contrast with this traditional view, this paper treats economies of diversification as a broader concept that includes economies of scope as a subset.

This paper defines economies of diversification by using profit function because firms can gain benefit from not just cost reduction stemming from joint production but also bundled sales. Economies of diversification exist if profit of multiproduct sales is greater than that of separate sales of products by specialized firms. In other words, economies of diversification can arise when firms purchase interrelated goods from markets and sell them by bundling. Therefore, economies of diversification can happen without economies of scope and under this definition, economies of scope, if exist, are only a factor that reinforces economies of diversification. According to the definition of economies of diversification, it becomes apparent that economies of scope are neither a necessary nor a sufficient condition for business portfolio diversification.

The concept can be more formally defined using superadditivity concept of mathematics. A multiproduct firm, selling multiple products, is said to gain benefit from economies of diversification if its profit function is strictly superadditive, i.e., for all non-negative $y_1$ and $y_2$

$$\pi(y_1, y_2) > \pi(y_1, 0) + \pi(0, y_2)$$

where $y_1$ and $y_2$ are sales of two products. If the superadditivity exists over some ranges of $y_1$ and $y_2$, the profit function is locally superadditive, and if it exists over all ranges of sales, the profit function is globally superadditive. If a firm has a superadditive profit function locally or globally, it has an incentive to diversify its business portfolio by selling multiple products.

Profit function is a linear combination of total revenue (TR) function and total cost (TC) function, so if all goods sold are produced by the same firm, Eq. (1) can be transformed into Eq. (2) and the roles of TR and TC in determining superadditivity of profit function can be identified.

$$TR(y_1, y_2) - TR(y_1, 0) - TR(0, y_2) > TC(y_1, y_2) - TC(y_2, 0) - TC(0, y_2)$$

As shown in Eq. (2), superadditivity of profit function depends on the curvature of total revenue curve and total cost curve. Four possible curvatures of profit function are shown in Table 1, and a profit function is definitely superadditive if TR curve is superadditive and TC curve is subadditive. A case in which both TR and TC curves are superadditive is not likely to occur because firms can avoid superadditive TC curve by simply purchasing a product in the market. By the same token, another case in which TR and TC curves are subadditive is also not likely to occur because firms can stop bundled sales, resulting in lower revenue. The last case where TR curve is subadditive and TC curve is superadditive is also an unthinkable possibility because firms can make this case not happen by changing their sales strategy or selling a part of production.
process. This means that firms have an incentive to diversify their business portfolio as long as they have either one of superadditive TR curve and subadditive TR curve or both.

### Table 1 SUPERADditIVITY OF PROFIT FUNCTION

<table>
<thead>
<tr>
<th>Curvature of TR curve</th>
<th>Curvature of TC</th>
<th>Superadditivity of profit function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Superadditive</td>
<td>Subadditive</td>
<td>Superadditive</td>
</tr>
<tr>
<td>Superadditive</td>
<td>Superadditive</td>
<td>Not likely to happen</td>
</tr>
<tr>
<td>Subadditive</td>
<td>Subadditive</td>
<td></td>
</tr>
<tr>
<td>Subadditive</td>
<td>Superadditive</td>
<td></td>
</tr>
</tbody>
</table>

### 2.2 SOURCES OF THE SUPERADDITIVITY OF PROFIT FUNCTION

In terms of demand side, bundling tends to increase profit when consumers have different willingness to pay for different products or demands are interrelated (Carlton & Perloff, 1999). If it does not, firms would not use it. Therefore, even when cost function is not subadditive, firms will diversify their business portfolio in order to increase profit by bundling. In this case, firms do not have to produce all the products they are selling as a bundle or independently. If there are no economies of scope and markets are competitive, firms can purchase some products from markets and tie them with their own products as long as bundling increases profit. As shown in Figure 1, consumers also have an incentive to participate in bundled consumption if they can benefit from it.

In terms of cost side, economies of scope can induce firms to diversify their business portfolio as it is traditionally illustrated by the previous literature (Baumol, Panzar, & Willig, 1982; Carlton & Perloff, 1999; Cooper, Diewert, & Wales, 2003; Teece, 1980). Chavas (2011) also points out that firms also have an incentive to diversify their businesses in order to reduce business risk.

### 2.3. BENEFITS OF USING PROFIT FUNCTION

Firms’ objective is often assumed to maximize profit, so it is more consistent with that assumption to use profit function rather than only cost function in order to describe or predict firms’ business diversification strategies. Especially when firms cannot choose optimal input mixes even in the long-run because of social customs, labor unions, and technological constraints, cost minimization assumption cannot be satisfied. Traditionally, however, existing studies on economies of scope are based on the cost minimization assumption, which could be much more stringent than actually it is expected to be.

In addition, it seems to be easier to test empirically the superadditivity of profit function than the subadditivity of cost function in studying business diversification behavior of firms mainly because it does not require the satisfaction of cost-minimization assumption. However, profit function approach has never been used before and the main reason would be the difficulty of estimating profit. Stock market can be said to be efficient because available information is instantaneously reflected in changes in stock prices. In addition, stock prices depend on firms’ profit in the long run. Therefore, profit can be estimated using stock price data and accounting data, which are often publicly available if firms are listed on stock market. This method of estimating profit was once
illustrated by Nam, Kwon, Kim, and Lee (2009). To sum up, if firms are listed on stock market, it is not impossible to estimate profit and to test the superadditivity of profit function.

3. BUNDLED CONSUMPTION OF SERVICES

Telecommunication networks often have been underutilized because they are designed to accommodate peak-time traffic. It has been impossible to efficiently use the networks when only voice calls were delivered through the networks. However, this nature of telecommunication networks has been drastically changing as they become common networks for multiple services. This section overviews increasing bundled consumption of telecommunication services.

Figure 2 SHARE OF CONSUMERS PURCHASING BUNDLED SERVICES IN THE UK

Figure 3 SHARE OF BUNDLED SERVICE CONSUMPTION IN THE UK

3.1. UK’S EXPERIENCES

According to Ofcom (2011, p. 45), as shown in Fig. 2, the proportion of bundled
consumption of telecommunications services has increased over the past decade. Specifically, during the last eight years, bundled consumption in the UK telecommunications industry has almost tripled. Among bundled services, as Fig. 3 illustrates, the bundle of fixed voice and broadband Internet is the first in popularity, the triple-play service tying multichannel TV with the two services is the second, and other, bundling more than three services including mobile service, is the third (Ofcom, 2011, p. 22). In mobile communications market, revenue from bundled service, as shown in Fig. 4, is about a third of total mobile retail revenue.

Figure 4 MOBILE RETAIL REVENUES IN THE UK (Ofcom, 2011, p. 288)

Figure 5 BUNDLED SUBSCRIPTION OF TELECOMMUNICATION SERVICES IN KOREA

3.2 KOREA’S EXPERIENCES

The Korean government allowed significant market players of the telecommunications industry to use bundling freely in 2007 as long as the maximum discount rate of bundled packages does not exceed 20% of the aggregated expenditure that consumers pay for individual services. In 2009, the government increased the maximum discount rate to
30%. After this liberalization, as shown in Fig. 5, bundled consumption of telecommunications services has surged in Korea.\(^3\) The proportion of triple play services (TPS) among bundled services, which was 16.7% at the first quarter of 2007, has been increasing and reached 30.1% at the third quarter of 2010 (Oh & Kang, 2011). Among various bundled packages, broadband Internet access is a basic component that consumers buy together with Cable or IPTV, fixed telephony, and mobile telephony (KISDI, 2010, p. 27). Similar trend is also found in European countries, where Internet access is included in 90% of bundles as of March 2011 (Eurobarometer, 2011, p. 80).

3.3 REASONS OF BUNDLING TELECOMMUNICATION SERVICES

As mentioned above, consumers get a discount and monetary and non-monetary benefits when they buy bundled packages, as shown in Fig. 1. In terms of firms, they can increase profit, reduce cost of production, and evade regulations by using bundling strategy (Carlton & Perloff, 1999). Additionally, telecommunications companies, confronted with market saturation, have an incentive to use bundling strategy in order to increase customer retention (Eurobarometer, 2011; Kwon & Kim, 2012).

In the telecommunications industry, services share the same specialized and indivisible assets such as networks, ducts, and poles. Put differently, they share the common fixed costs, which are often sunk, and thus telecommunications firms have an incentive to bundle multiple services. Nowadays, the Internet is the common asset that is used for the delivery of multiple services such as access, fixed telephony, and TV signals. In case of the Internet using ADSL technology, Internet access and fixed telephony shared the same access network between local exchanges and homes, so it was more efficient for NOs to provide the two services together. As Teece (1980) pointed out, the existence of shared input does not necessarily mean that one firm should provide two services together because, through local loop unbundling, separate firms can provide each service separately. The same is also true of the relationship between VoIP and the Internet, but at this time, VoIP is an accessory and Internet access is the principal.

4. ECONOMIES OF SCALE AND SCOPE IN THE WIRELESS TELECOMMUNICATIONS INDUSTRY

In order to estimate quadratic cost function, it is necessary to collect output and input price data (Cooper, Diewert, & Wales, 2003; Diewert, & Fox, 2009). As voice revenue becomes smaller and output mix becomes diversified as shown in Fig. 4 and Kwon and Kim (2012), the ways to measure outputs need to be discussed. Therefore, in the following subsection, this subject is first explored and then economies of scale and scope in the wireless telecommunications industry are discussed.

4.1 WAYS TO MEASURE OUTPUTS IN THE WIRELESS COMMUNICATIONS INDUSTRY

Even though normalized output data are often used in cost function estimation, outputs
have to be measured first before normalization. A simple measure of output in the wireless telecommunications industry is the number of subscribers and the long-run average cost curve (LRAC) can be drawn with respect to that subscriber number (Nam et al., 2009) or call minutes.

Table 2 CELLPHONE RATE PLANS

<table>
<thead>
<tr>
<th>Network operator</th>
<th>Monthly charge</th>
<th>Free volume</th>
<th>Usage charge</th>
</tr>
</thead>
<tbody>
<tr>
<td>Verizon Wireless (USA)</td>
<td>$59.99 (Talk &amp; Text)</td>
<td>450 minutes, Unlimited messages</td>
<td>45 cents per minute</td>
</tr>
<tr>
<td></td>
<td>$79.99 (Talk &amp; Text)</td>
<td>900 minutes, Unlimited messages</td>
<td>40 cents per minute</td>
</tr>
<tr>
<td></td>
<td>$89.99 (Talk &amp; Text)</td>
<td>Unlimited minutes and messages</td>
<td>-</td>
</tr>
<tr>
<td>Orange (UK)</td>
<td>£20 (Dolphin 20)</td>
<td>300 minutes, Unlimited messages</td>
<td>20 pence per minute</td>
</tr>
<tr>
<td></td>
<td>£25 (Dolphin 25)</td>
<td>500 minutes, Unlimited messages</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>£30 (Dolphin 30)</td>
<td>800 minutes, Unlimited messages</td>
<td>-</td>
</tr>
<tr>
<td>KT (Korea)</td>
<td>21,000 Korea Won (Show i-slim)</td>
<td>150 minutes, 200 messages, 100MB</td>
<td>18 Won per 10 seconds, 20 Won per message, 0.025 Won per 0.5KB</td>
</tr>
<tr>
<td></td>
<td>28,000 Korea Won (Show i-light)</td>
<td>200 minutes, 300 messages, 500MB</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>54,000 Korea Won (Show i-special)</td>
<td>600 minutes, 300 messages, 1.5GB</td>
<td>-</td>
</tr>
</tbody>
</table>

* All plans require 24 month contract.
* Source: each firm’s homepage (www.verizonwireless.com, www.orange.co.uk, www.show.co.kr)

As shown in Fig. 4, subscribers now often use cellphones for data connection, messaging, and voice communications in varying combinations. In the previous research such as Bloch, Madden, and Savage (2001), and Cooper et al. (2003), local and toll call minutes are used as output data. Nowadays, as shown in Table 2, units of data measurement are not homogeneous: megabytes for data connection, integer number for messaging, and call minutes for voice. Therefore, outputs are more heterogeneous than those used in studies of a decade.

Among three kinds of services, data traffic is rapidly increasing, while, as mobile market saturates, the number of cellphone subscribers is stagnant (Kwon & Kim, 2012). Exploding data traffic forces MNOs to upgrade their network and to acquire more spectrum for wireless communication while there is no growth in subscribers. These market developments will inevitably cause capital cost of MNOs to grow in the near future and make the number of subscribers lose its validity as a measure of output in the wireless communications industry because it is not a major cost and revenue driver any longer. Data traffic is also the driving force that creates changes in revenue of MNOs. Fig. 6 illustrates the increasing importance of data revenue and implies that the number of subscribers does not reflect the dynamic changes in revenue mix. Therefore, data traffic becomes a more important output in the mobile communications. In the future, if mobile VoIP replaces circuit switching call service, there will be no difference in
measurement among three types of outputs.

Figure 6 DATA AND CALL REVENUE OF SK TELECOM (unit: billion Korean Won)

![Figure 6](image)

Figure 7 THE SHARE OF FIXED FEES TO TOTAL VOICE REVENUE

![Figure 7](image)

Three-part tariffs as shown in Table 2 are widely used nowadays especially after smartphones are introduced. Under the three-part tariff, a large share of revenue depends on monthly fixed payments and the share of fixed monthly payments to total voice call revenue is rising. This implies that more of revenue does not depend on actual traffic, gradually alienating the relationship between cost and revenue. As shown in Fig. 7, the ratio of fixed fees (one-off subscription fee plus fixed monthly charge) to total voice revenue has been rising since 3G service was introduced in Korea in 2007 and the trend becomes more vivid after smartphones were introduced at the end of 2009.

In conclusion, the number of subscribers and call minutes which are stagnant or falling
are not appropriate output measures that can be used to study the subadditivity of cost function as well as superadditivity of profit function.

4.2 ECONOMIES OF SCALE AND SCOPE IN THE WIRELESS TELECOMMUNICATIONS INDUSTRY

This subsection focuses on economies of scale and scope that are happening in the Korean telecommunications market. According to Teece (1980), the existence of an indivisible asset, telecommunications network, is a factor that results in economies of scope. In other words, if there is an indivisible common asset that can be shared for multiple services, it is likely to be better for one firm to provide multiple services together than for multiple firms to offer specialized services respectively. This will lead to cost complementarities, indicated as a sufficient condition for the presence of economies of scope in Hajargasht, Coelli, and Rao (2008). 3G wireless communications network can be considered as an indivisible common asset because three kinds of outputs are delivered through the network.

Figure 8 SKT’S ESTIMATED REAL COSTS OF SERVICE (unit: trillion Won)

In order to understand the impact of fast growing data service on the cost of MNOs, first a firm’s total cost data should be obtained. From the quarterly Earnings Results that SKT publishes quarterly, operating expense data and total asset data are collected. It is necessary to sort out some assets that are not use for business from total assets. According to NICE Information Service, evaluating credit ratings of Korean firms, the amount of invested capital (IC), which means the amount of capital used actually for business, is on average about 50% of total assets. Then, nominal cost of capital is calculated by multiplying IC to a WACC (weighted average cost of capital), which is five-year average WACC obtained from NICE Information Service. Total costs of SKT are finally derived by adding operating expenses with nominal cost of capital. Total costs of SKT and nominal cost of capital are deflated by CPI in order to get real costs of service. Total costs are then classified into fixed and variable costs. Fixed cost includes cost of
capital, depreciation, and expenditures for advertising, interconnection, leased lines. Trends of fixed cost, variable cost, and total cost are presented in Fig. 8, in which real fixed cost has been stable for the past ten years while real variable cost has grown significantly.

Superficially, almost flat total fixed cost curve seems to look odd because MNOs have upgraded their networks to launch 3G service since 2006 and for accommodating exploding data traffic since 2009 in Korea. However, this odd finding may not look odd if we consider that prices of telecommunication equipment have declined significantly over the past ten years.

In order to calculate long-run average cost (LRAC), output variable must be chosen and three output variables are available: the number of subscribers, call minutes, and traffic. While the number of subscribers grows sluggishly, call minutes per user are stagnant. Therefore, in order to see the effect of growing data traffic on LRAC, data service output measure is used here. However, firm level traffic data are not available, so a data service traffic index is created and used. The data service traffic index used in this paper is generated based on the assumption that data traffic grows exponentially since 2007. 3G service started from 2007, so data traffic before 2007 is, if any, considered being 1. Then data traffic since 2007 is assumed to grow exponentially with 4% growth rate per quarter.

Figure 9 SKT’S AVERAGE COSTS CURVES (unit: Korean won per pseudo subscriber)

![Figure 9 SKT’S AVERAGE COSTS CURVES](image)

The derived data traffic index is multiplied to the number of subscribers in order to convert pure subscriber numbers into pseudo subscriber numbers that reflect changes in data traffic. The index is one for years before 2007, which means that there is no difference between subscriber numbers and pseudo subscriber numbers. Since 2007, pseudo subscriber numbers are greater than actual subscriber numbers because actual subscriber numbers are multiplied by the index. It is obvious that this is an arbitrary way
of calculating output data but notwithstanding it is also one practical way to calculate because it is well known that data traffic is growing exponentially nowadays (Kwon & Kim, 2012). Fig. 9 presents declining LRAC curves. Average total cost (ATC), average fixed cost (AFC), and average variable cost (AVC) are all declining and this implies the existence of strong economies of scale caused by rapidly growing data traffic.

Figure 10 SKT’S AVERAGE COST CURVES (unit: Korean won per subscriber)

![Figure 10 SKT’S AVERAGE COST CURVES (unit: Korean won per subscriber)](image)

Figure 11 SKT’S AVERAGE COST CURVES (unit: Korean won per call minute)

![Figure 11 SKT’S AVERAGE COST CURVES (unit: Korean won per call minute)](image)

If actual subscriber numbers or call minute numbers are used as output data, it is not easy to see if there exist economies of scale with respect to an output variable. Figs. 10 and 11 show LRAC curves which are drawn against the number of subscribers and call
minutes, the multiplication of subscribers and average incoming and outgoing call minutes. In both figures, AFC curve is downward sloping and ATC curve is also sloping downward even though it is almost flat, while AVC curve is not.

5. CONCLUSION

Analyses of this paper show that real fixed cost has been stable for the past ten years as shown in Fig. 8. Even though data traffic has skyrocketed in Korea since 2009, fixed cost has been stable. Two interpretations seem to be possible. One is that there has been significant amount of underutilized facilities and equipment in the wireless telecommunications industry. Therefore, it has been possible for MNOs to accommodate fast growing data traffic without a significant increase in investment. The other is that MNOs actually increased their investment in facilities to accommodate increasing data traffic, but increases in physical assets have not been noticeable in money value because of falling prices of equipment. In either case, growing data traffic does not seem to have increased cost of capital significantly for the past few years.

Mainly because of lack of available data, estimating cost function is extremely difficult and estimating profit function does not look easy either. Especially, as more of subscribers adopt three-part tariffs, separating revenue to multiple services becomes more problematic. It is hard to find meaningful price data if most subscribers use services within inclusive call, messaging, and data volumes. These difficulties urge researchers to devise practical ways of estimating cost and profit functions for policy purposes. This paper shows that using a pseudo subscriber number we can illustrate the impact of growing data traffic on average cost curves.

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REFERENCES


ENDNOTES

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2 Data for Figure 1 are from Ofcom (2010, p. 60).
3 Data are from Oh and Kang (2011).
4 Bloch, Madden, Coble-Neal, and Savage (2001) reports output variables used in the previous research.
on the cost function of telecommunication firms.

5 Table 2 is copied from Kwon (2011).
6 Mobile data traffic has increased about 13 times between January of 2010 and that of 2011.