The Economies of Scale and Scope

of the Japanese Local Telecommunications:

Basic Service vs. Advanced Service

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Abstract:
This letter will take an example from the Japanese local telecommunications industry in the 1990s and analyze the cost structures of a basic service and an advanced service, focusing on the economies of scale and scope. Here, the basic service is defined as the plain old telephone service (POTS) while the advanced service the leased circuit service. There are three points we will make: first, the economies of scale do not exist in the telephone service; second, the economies of scale exist in the leased circuit service; third, the economies of scope exist between them.

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I. Introduction

The economies of scale and scope have been a central concept for both theoretical and empirical research concerning the telecommunications industry. However, most efforts have been devoted to study the economies of scale and scope of long-distance and local call services (see Kiss et al. (1983), Roeller (1990) for example). Even though there are several empirical studies that dealt with the local telecommunication services, they mainly focus on the economies of scale and scope of the local call service and the toll service.

Recently, the broadband, high-speed services have rapidly spread in the local telecommunications industry, and this industry has changed from a naturally monopolistic one to a competitive one. This letter will take an example from the Japanese local telecommunications industry in the 1990s and analyze the cost structures of a basic service and an advanced service, focusing on the economies of scale and scope. Here, the basic service is defined as the plain old telephone service (POTS) while the advanced service the leased circuit service.

There are three main points we will make: first, the economies of scale do not exist in the telephone service; second, the economies of scale exist in the leased circuit service; third, the economies of scope exist between them. Some policy implications will be obtained from these empirical results. To begin with, the economies of scale will not provide a rationale for the traditional view that telephone should be a regulatory service while leased circuit a competitive one, depending on their characteristics of the economies, or diseconomies, of scale. Next, an incumbent telephone company that has already provided a basic service such as telephone will have a competitive advantage in terms of cost as it additionally provides an advanced service such as leased circuit.

II. Model, Definitions and Data

We assume here a cost function that consists of three inputs of labor force, material, and capital and two outputs of telephone and leased circuit as follows:

\[ C = C (P_L, P_M, P_K, Y_1, Y_2, t) \]  

(1)
given \( L=\text{labor} \), \( M=\text{material} \), \( K=\text{capital} \),
\( Y_1=\text{telephone} \), \( Y_2=\text{leased circuit} \), and \( t=\text{time trend} \).

Furthermore, we suppose the cost function to be a hybrid translog cost function, which is a special case of the generalized multiproduct translog cost function developed by Caves et al. (1980) \(^3\). The hybrid translog cost function can be evaluated even in the case where some of the output values are assumed to be zero, which is an important property if the economies of scale and scope is to be investigated \(^4\). The hybrid translog cost function is defined as follows:

\[
\ln C = \alpha_0 + \sum_{i=L,M,K} \alpha_i \ln P_i + \frac{1}{2} \sum_{j=L,M,K} \beta_{ij} \ln P_i \ln P_j \\
+ \sum_{i=1,2} \gamma_i Y_i + \frac{1}{2} \sum_{i=1,2} \sum_{j=1,2} \delta_{ij} Y_i Y_j + \sum_{i=L,M,K} \sum_{j=1,2} \rho_{ij} \ln P_i Y_j \\
+ \tau_t + \frac{1}{2} \tau_{tt} t^2. 
\] (2)

Three inputs prices are defined as follows:
\( P_L \): the labor price = the personnel expenses / the number of employees at the end of the fiscal year \(^5\),
\( P_M \): the material price = the non-personnel expenses / the number of telephone subscriptions at the end of the fiscal year,
\( P_K \): the capital price = the price index of the capital goods \times (\text{the interest rate of the government guaranteed bonds + the rate of depreciation}) \(^6\),
given the rate of depreciation = the depreciation expenses / the equipment expenses at the beginning of the fiscal year.

Also two outputs are defined as follows:
\( Y_1 \): the total minutes of local call,
\( Y_2 \): the total number of leased circuits \(^7\).

All data are normalized by their mean values.

We assume the following constraints of linear homogeneity with regard to input prices in advance:

\[
\sum_{i=L,M,K} \alpha_i = 1, \sum_{j=L,M,K} \beta_{ij} = \sum_{j=L,M,K} \rho_{ij} = \sum_{i=L,M,K} \lambda_i = 0. 
\] (3)
At the same time, we assume the following symmetry of second-order partial derivatives with regard to input prices:

\[ \beta_{ij} = \beta_{ji}. \] (4)

From Shepherd’s lemma, the share equations of inputs (i=L,M,K) are obtained as follows:

\[ \frac{\partial \ln C_i}{\partial \ln P_i} = \frac{\partial C_i}{\partial P_i} \frac{P_i}{C_i} = \alpha_i + \sum_{j=L,M,K} \beta_{ij} \ln P_i + \sum_{j=1,2} \rho_{ij} Y_j + \lambda_i \ln t. \] (5)

The total cost that is the explained variable is the sum of the personnel expenses, the material cost, and the capital cost. The capital cost is defined as the product of the capital stock and the capital price, and the capital stock is defined as follows:

the capital stock = (1- the rate of depreciation)×the capital stock at the previous term + the real gross investment,

given the real gross investment = the amount of annual change of the fixed assets + the depreciation expenses.

We can now estimate the simultaneous equations of the hybrid translog cost function, with the constraints of the linear homogeneity and the second-order symmetry, and the share equations of labor and material by the Zellner’s seemingly unrelated regression (SUR) method. The data are extracted from the eleven NTT’s regional offices from 1992 to 1997.

We will move on to define the economies of scale and scope. First, the product-specific economies of scale are defined as follows:

\[
\text{SCALE}(Y_1) = 1 - \left[ \frac{\partial C(Y_1, Y_2)}{\partial Y_1} \right] \times \left[ \frac{Y_1}{C(Y_1, Y_2) - C(0, Y_2)} \right]
\]

\[
\text{SCALE}(Y_2) = 1 - \left[ \frac{\partial C(Y_1, Y_2)}{\partial Y_2} \right] \times \left[ \frac{Y_2}{C(Y_1, Y_2) - C(Y_1, 0)} \right].
\] (6)

If these figures are positive (negative), the product-specific economies (diseconomies) of scale exist. Second, the economies of scope are defined as follows:

\[
\text{SCOPE} = \frac{C(Y_1, 0) + C(0, Y_2) - C(Y_1, Y_2)}{C(Y_1, Y_2)}.
\] (7)

If this figure is positive (negative), the economies (diseconomies) of scope exist.

### III. The result of the estimation
First, Table 1 shows the result of the estimation. A high correlation between the outputs of telephone and leased circuit is expected in the estimation. Thus the problem of multi-collinearity may occur. However, it appears that the result is quite good. The R²s are high, and most estimates are statistically significant at the 5 or 10 % level.

<Table 1>

Next, Table 2 indicates the result of the test of the economies of scale and scope at the point where the figures are mean values. The following can be observed here.

<Table 2>

Observation 1. The economies of scale do not exist in the telephone service.

Because SCALE(Y₁) is negative (-0.54727), the economies of scale do not exist in the telephone service; on the contrary, the diseconomies of scale exist. However, as we carry out the Wald test, the value of χ² is 2.0416 (the p-value is 0.1530), and therefore we cannot reject the null hypotheses of the constant return to scale.

Observation 2. The economies of scale exist in the leased circuit service.

Because SCALE(Y₂) is positive (0.29969), the economies of scale exist in the leased circuit service. As we carry out the Wald test, the value of χ² is 22.3155 (the p-value is 0.0000), and therefore we can clearly reject the null hypotheses of the constant return to scale.

Observation 3. The economies of scope exist between the telephone and leased circuit services.

Because SCOPE is positive (0.46868), the economies of scope exist between the telephone and leased circuit services. As we carry out the Wald test, the value of χ² is 12.1853 (the p-value is 0.0005), and therefore we can clearly reject the null hypotheses
of the zero scope economies.

IV. Conclusion

The following conclusions can be reached. First, we have not found that the economies of scale exist in the telephone (local call) service, which has been regulated because of its characteristic of the scale economies. On the other hand, we have confirmed that the economies of scale exist in the leased circuit service, which is considered as a competitive service. That is to say that since the economies of scale do not work in the basic service whose nationwide development had already been completed whereas they do in the advanced service that is currently spreading, it is difficult to discern between a regulated service and a competitive service on the basis of the economies of scale. Second, since there exist the scope economies, an incumbent telephone company that has provided the telephone service has a competitive advantage in terms of cost when it additionally provides the leased circuit service. However, if we take account of the universal service obligation that an incumbent company often imposes, it seems quite difficult to judge whether the incumbent company can really maintain its market share from the cream skimming of an entrant.
References


Table 1. The result of the estimation

<table>
<thead>
<tr>
<th>Estimate, Coefficient (Standard error)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\alpha_0$</td>
</tr>
<tr>
<td>$\alpha_L$</td>
</tr>
<tr>
<td>$\alpha_M$</td>
</tr>
<tr>
<td>$\beta_{LM}$</td>
</tr>
<tr>
<td>$\beta_{LK}$</td>
</tr>
<tr>
<td>$\beta_{MK}$</td>
</tr>
<tr>
<td>$\gamma_1$</td>
</tr>
<tr>
<td>$\gamma_2$</td>
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<tr>
<td>$\delta_{i1}$</td>
</tr>
<tr>
<td>$\delta_{i2}$</td>
</tr>
<tr>
<td>$\rho_{1M}$</td>
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<td>$\rho_{1K}$</td>
</tr>
<tr>
<td>$\rho_{2M}$</td>
</tr>
<tr>
<td>$\rho_{2K}$</td>
</tr>
<tr>
<td>$\tau_i$</td>
</tr>
<tr>
<td>$\tau_{it}$</td>
</tr>
</tbody>
</table>

Note 1. Adjusted $R^2$: the cost function, 0.970; the labor share equation, 0.814; the fuel share equation, 0.680

Note 2. ** statistical significance at the 5% level, * statistical significance at the 10% level

Table 2. The economies of scale and scope

<table>
<thead>
<tr>
<th>Estimate (Standard error)</th>
<th>SCALE($Y_1$)</th>
<th>SCALE($Y_2$)</th>
<th>SCOPE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>-0.54727 (0.38301)</td>
<td>0.29969 (0.06344)**</td>
<td>0.46868 (0.13426)**</td>
</tr>
</tbody>
</table>

Note. ** statistical significance at the 5% level, * statistical significance at the 10% level
Footnotes

1 See Bohlin (1997), Hayashi and Fuke (2000), and Tsuji (2000) for the comprehensive description with regard to the regulatory reform in Japan’s telecommunications.

2 There are insufficient data on such new services as xDSL and FTTH enough to be empirically verified. Instead, we considered the leased circuit service as a sort of proxy of new services.

3 See also Pulley and Braustein (1992), Mackenzie (1997), Toft and Bjorndal (1997) for further information.

4 Otherwise, we may utilize the generalized translog cost function that carries out Box-Cox transformation or the symmetrically generalized McFadden cost function so that we can insert zero into the cost function. See Asai (2001) in detail.

5 The data are extracted from Statement of Income and Financial Report of NTT on each fiscal year.


7 The total number of leased circuits is the sum of the general leased circuit and the high-speed digital circuit, which is transformed into the corresponding number of telephone lines.

8 The data of regional offices became available when the regional company system of NTT was introduced in 1992. However, the release of the data ended in 1997 because the reorganization of NTT was agreed in 1996.