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On the Regional Gap of the Japanese Local Telecommunications

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Abstract

The focus of the Japanese local telecommunications policy is moving towards how to solve the problem of digital divide that accompanies the spread of high-speed and broadband services. This paper estimates the translog cost function of two outputs, the telephone service and the leased circuit service, and measures the regional gap of those stand-alone costs and incremental costs. The main point we will make is: the cost gap of the leased circuit service is larger than that of the telephone service between the eleven NTT's regional offices.

JEL classifications: L52, L96

Keywords: telecommunications, cost function, stand-alone cost, incremental cost, universal service

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1. Introduction

Although the regulatory reform of the Japanese telecommunications industry was slow in comparison with those of the U.S.A and the U.K., it has been gradually catching up with them after the dispute between NTT and the government over the reforms. At present, competition is emerging even in the local call market, which was effectively a NTT monopoly for a long period, with extensive restructuring and deregulation. However, the new entry in the local telephone market is limited only in the heavily populated urban center, and the 'digital divide' of the high-speed and broadband services such as xDSL and FTTH between urban areas and rural areas is becoming a new political problem.

This paper will estimate the long-run translog cost function of multiple services, based on Palmer's method, measure the stand-alone costs and the incremental costs, and thus calculate the different costs in each region of the Japanese local telecommunications. The main conclusions can be summarized as follows. When the average stand-alone costs and the average incremental costs of the telephone service and the leased circuit service are compared between the eleven NTT's regional offices, the cost gap of the leased circuit service is larger than that of the telephone service. It seems from what has been stated that the problem of regional gap is serious not in the conventional service that has spread very widely but in the newly developing service in which the multiplexing of the network plays an important role such as high-speed and broadband services.

The paper consists of the following eight sections. Section 2 briefly surveys the Japanese universal service policy, Section 3 explains the method of the cost estimation, and Section 4 represents the result of the estimation. Section 5 provides the definitions of stand-alone costs and incremental costs, whilst Section 6 analyzes the calculated costs from both viewpoints of cross-section and time-series. Section 7 examines the implications for the telecommunications policy, and finally Section 8 draws a conclusion.

2. An overview of the Japanese universal service policy

It will be helpful to survey the Japanese universal service policy before moving on to the main subject[1]. The object of the present universal service of Japan, like many other countries, is the fixed-line telephone service whose nationwide development had already been completed by 1985, when Nippon Telegraph and Telephone (NTT) was privatized and the telecommunications market was liberalized. While the argument in

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[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. Empirical studies such as Nakajima and Hatta (1993), Tachibanaki and Irie (1994), Oniki, et al. (1994) and Sueyoshi (1996) are also informative.

favor of universal service were hardly put forward at all at the introduction of competition, only NTT was determined to impose the universal service obligation because in the past it had this characteristic as a public corporation. However, it should be noted that this obligation was a sort of expected duty written in NTT Corporation Law but this obligation on NTT was not clearly stated in the Telecommunications Business Law.

The question of why the prescription of the Japanese universal service was ambiguous may arise. It will be necessary to explain the long debate concerning the management structure of NTT in order to understand this. After the privatization of NTT in 1985 and the new entry of New Common Carriers (NCCs) in 1987, the main issue that needed to be dealt with in the area of competition policy was how to ensure the conditions for fair and effective competition between NTT, which was a bottleneck monopoly in the local call market, and the long-distance NCCs, which did not hold the local loop. Although the Ministry of Posts and Telecommunications (MPT) considered the reorganization of the management structure of NTT, including its divesture, in 1990, a consensus could not be reached and the issue was postponed for five years.

In the meantime, NTT divided itself into a long-distance operation division and the eleven regional offices in 1992 and introduced an accounting separation among them; furthermore, NTT reached agreement with the long-distance NCCs, such as DDI, JT, and TWJ, to introduce an access charge based on an end-to-end tariff system. NTT also announced the open network policy, which represented NTT's spontaneous nondiscriminatory interconnection scheme. However, since NTT continued to be a substantial monopoly in the local call market in spite of such a series of reforms, the conflicts between NTT and NCCs with respect to interconnection occasionally occurred. Finally, in 1996, MPT and NTT agreed on the reorganization of NTT under a new holding company scheme: NTT would be reorganized into one long-distance company (NTT-Communication) and two regional companies (East NTT and West NTT) under the ownership of the holding company which would also inherit the NTT's R&D. In 1999, the new NTT group was established. After the problem of the management structure of NTT was solved in this way, the regulatory reform in the Japanese telecommunications industry itself began to make rapid progress[2].

More than fifteen years have passed since liberalization and privatization were carried out: at present, the local NCCs such as subsidiaries of electric power companies and

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[2] Specifically, after the reorganization of NTT, the following regulatory reforms have been carried out. First, the charge regulation was reformed so that the long-distance and international services could be priced completely freely while the local call service was regulated with a price cap instead of the previous rate-of-return regulation from 2000. Second, as for the reform of access charge, the long-run incremental cost rule was adopted from 2000, and furthermore NTT promised to reduce the level of charge by 20% within two years. Third, as for the problem of equal access, the dialing parity system was introduced from 2001 and also a number portability would start after that.

CATV companies have entered into the local call market, and a competition has started to emerge even there. Accordingly, it is not becoming reasonable to impose the universal service obligation on only East and West NTT from the viewpoint of level-playing-field because other local call companies tend to behave in an opportunistic way. Due to such recognition, when the telecommunications Business Law was revised in 2001, the plan was announced for a new external subsidiary system that should be competitively neutral. While the specific design of a universal service fund is a matter under consideration, this paper intends to present a basis for the policy discussion[3].

3. The method of the estimation of cost function

In this section, the method of estimation will be explained. We assume here a cost

[3] One effective approach toward the universal service policy is the method of calculating long-run incremental cost based on the engineering cost model. This approach deserves more than passing attention. However, this has two shortcomings. First, an incumbent firm may fail to recover the embedded cost of the past investment for plant-and-equipment in the case where technical progress has been remarkable, since the plant-and-equipment that used to be the most efficient technology becomes inefficient at the time of the cost calculation. Second, the current Japanese universal service policy covers only the plain old telephone service (POTS). Nevertheless, since the actual telephone companies jointly produce several services other than POTS, it is necessary to take account of the joint cost of offering multiple products.

function that consists of three inputs of labor force, raw material, and capital and two outputs of telephone and leased circuit as follows:

$$C= C (P_L, P_M, P_K, Y_1, Y_2, t), \quad (1)$$

given L=labor, M=material, K=capital,

Y_1=telephone, Y_2=leased circuit, and t=time trend.

Furthermore, we suppose the cost function to be a translog cost function, which is known as a type of flexible cost function. One purpose of this paper is to measure stand-alone costs and incremental costs. For that, since we need to insert the value of zero into the cost function, we cannot directly measure stand-alone costs and incremental costs with the translog cost function. 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[4]. Asai (2001) previously estimated the generalized translog cost function with Box-Cox transformation in order to measure stand-alone costs and incremental costs, although the problem of multi-collinearity was pointed out since the Box-Cox transformed quantities showed a high degree of correlation (note: the correlation coefficient was 0.915). Whereas the adoption of the cost function of McFadden's type is a future subject worthy of consideration, it should be noted that Röller (1990) pointed out the non-robustness around the domain of zero when the generalized functional form is assumed.

[4] See also Pulley and Braustein (1992), Mackenzie (1997), Toft and Bjorndal (1997) for further methods. They assumed a linear function instead of a logarithmic function for outputs.

Thus, based on Palmer's method (see Palmer 1991, 1992), we will measure stand-alone costs and incremental costs without directly inserting zero into the translog cost function. The translog cost function is defined as follows:

$$
\begin{aligned}
\ln C = \alpha_0 &+ \sum_{i=L,M,K} \alpha_i \ln P_i + \frac{1}{2} \sum_{i=L,M,K} \sum_{j=L,M,K} \beta_{ij} \ln P_i \ln P_j \\
&+ \sum_{i=1,2} \gamma_i \ln Y_i + \frac{1}{2} \sum_{i=1,2} \sum_{j=1,2} \delta_{ij} \ln Y_i \ln Y_j + \sum_{i=L,M,K} \sum_{j=1,2} \rho_{ij} \ln P_i \ln Y_j \qquad (2) \\
&+ \sum_{i=L,M,K} \lambda_i \ln P_i t + \sum_{i=1,2} \theta_i \ln Y_i t + \tau_t t + \frac{1}{2} \tau_{tt} t^2 + \sigma D \ln Y_2 .
\end{aligned}
$$

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 × (the interest rate of the government guaranteed bonds + the rate of depreciation)[6],

given the rate of depreciation = the depreciation expenses / the equipment

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

[6] See Monthly Price Index Report by Bank of Japan about the price index of the capital goods and Monthly Economic Statistics Report by Bank of Japan about the interest rate of the government guaranteed bonds.

expenses at the beginning of the fiscal year.

Also two outputs are defined as follows:

Y_1: the total minutes of telephone call,

Y_2: the total number of leased circuits[7].

Since the scale of market and the density of demand vary across regional offices, we adopt the dummy variables (D=1) for the output of leased circuit of Tokyo, Kanto, Tokai, and Kansai. Furthermore, we assume the following constraints of linear homogeneity with regard to input prices in advance:

$$\sum_{i=L,M,K} \alpha_i = 1, \sum_{j=L,M,K} \beta_{ij} = \sum_{j=L,M,K} \rho_{ij} = \sum_{i=L,M,K} \lambda_i = 0. \quad (3)$$

At the same time, we assume the following symmetry of second-order partial derivatives with regard to input prices:

$$\beta_{ij} = \beta_{ji}. \quad (4)$$

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

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

The total cost that is the explained variable is the sum of the personnel expenses, the

[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.

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 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 maximum likelihood (ML) method. The data are extracted from the eleven NTT's regional offices from 1992 to 1997[8]. Fig. 1 displays a map of the eleven NTT's regional offices for reference. Table 1 also presents the average outputs of the telephone service and the leased circuit service of each regional office each year. There are two points to note here. The first is that outputs of the larger regional offices, such as Tokyo, Kanto, Tokai and Kansai, which are operating in the metropolitan areas, such as Tokyo, Nagoya and Osaka, are quite different from those of other smaller regional offices. The second is that the growth

[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. Therefore, there is an inconsistency in NTT's data before and after 1997. This is the reason the amount of data is quite limited for this analysis.

rate of the telephone service decreased drastically in the years after 1995 while that of the leased circuit service has consistently risen.

<Fig. 1>

<Table 1>

4. The result of the estimation

This section will show the result of the estimation. A high correlation between the outputs of telephone and leased circuit is observed in the estimation; in particular, the correlation coefficients between the first-order term and the second-order term of the telephone service, Y_1 and Y_1^2, and the leased circuit service, Y_2 and Y_2^2, are higher than 0.95. Thus the problem of multi-collinearity would occur. At this point, we drop the second-order terms in order to avoid this problem. The result of the estimation is displayed in Table 2.

<Table 2>

Next, we turn to investigate the properness of the functional form. Having assumed that the cost function is linear homogeneous with regard to input prices, it is sufficient that we check the conditions that the cost function, first, is non-decreasing with regard to input prices and output quantities and, second, is concave with regard to input prices in order to prove the properness. These conditions are in fact satisfied for all samples.

5. The definitions of stand-alone cost and incremental cost

In this section, we will provide the definitions of stand-alone cost and incremental cost. To define stand-alone cost and incremental cost, we need to insert the value of zero into the cost function, but the translog cost function does not permit this. As stated before, we will here measure the stand-alone cost and the incremental cost on the basis of Palmer's method. According to this method, the stand-alone cost and the incremental cost can be defined as follows on condition that the economies of scale are constant.

The stand-alone cost of the telephone service, $SAC(Y_1)$, and the leased circuit service, $SAC(Y_2)$:

$$SAC(Y_1) \equiv C(Y_1, \underline{Y}_2) - \underline{Y}_2 \frac{\partial C(Y_1, Y_2)}{\partial Y_2}\Big|_{Y_2 = \underline{Y}_2}, \qquad (6)$$

$$SAC(Y_2) \equiv C(\underline{Y}_1, Y_2) - \underline{Y}_1 \frac{\partial C(Y_1, Y_2)}{\partial Y_1}\Big|_{Y_1 = \underline{Y}_1}, \qquad (7)$$

given that $\underline{Y}_i$ represents an arbitrary value; here we will adopt the average value of the i-good of each regional office from 1992 to 1997 as the standard value.

The incremental cost of the telephone service, $IC(Y_1)$, and the leased circuit service, $IC(Y_2)$:

$$IC(Y_1) \equiv C(Y_1, Y_2) - SAC(Y_1) \qquad (8)$$

$$IC(Y_2) \equiv C(Y_1, Y_2) - SAC(Y_1). \quad (9)$$

We will explain the definitions above. Originally, since the stand-alone cost of the telephone service and the incremental cost of the leased circuit service are defined as $C(Y_1, 0)$ and $C(Y_1, Y_2) - C(Y_1, 0)$ respectively, we obtain the following equations:

$$SAC(Y_1)=C(Y_1, 0) \quad \Leftrightarrow \quad IC(Y_2)=C(Y_1, Y_2) - C(Y_1, 0) \quad (10)$$

$$\Leftrightarrow \quad \frac{C(Y_1,\underline{Y}_2)-C(Y_1,0)}{\underline{Y}_2} = \frac{\partial C(Y_1,Y_2)}{\partial Y_2}\Big|_{Y_2=\underline{Y}_2}.$$

Likewise, since the stand-alone cost of the leased circuit service and the incremental cost of the telephone service are defined as $C(0, Y_2)$ and $C(Y_1, Y_2) - C(0, Y_2)$ respectively, we obtain the following equations:

$$SAC(Y_2)=C(0, Y_2) \quad \Leftrightarrow \quad IC(Y_1)=C(Y_1, Y_2) - C(0, Y_2) \quad (11)$$

$$\Leftrightarrow \quad \frac{C(\underline{Y}_1,Y_2)-C(0,Y_2)}{\underline{Y}_1} = \frac{\partial C(Y_1,Y_2)}{\partial Y_1}\Big|_{Y_1=\underline{Y}_1}.$$

The necessary and sufficient condition that the definitions of stand-alone cost and incremental cost given above are equal to these original definitions is that the average incremental cost is equal to the marginal cost in the standard value, which represents the fact that the product-specific scale economies are constant.

As a matter of fact, the product-specific scale economies are not always constant, or rather they occasionally exist, in the telecommunications industry. In the case where the scale economies of the leases circuit service exist, we obtain the following inequalities:

$$SAC(Y_1)>C(Y_1, 0) \quad \Leftrightarrow \quad IC(Y_2)<C(Y_1, Y_2) - C(Y_1, 0) \qquad (12)$$

$$\Leftrightarrow \quad \frac{C(Y_1,\underline{Y}_2)-C(Y_1,0)}{\underline{Y}_2} > \frac{\partial C(Y_1,Y_2)}{\partial Y_2}\Big|_{Y_2=\underline{Y}_2}.$$

Likewise, in the case where the scale economies of the telephone service exist, we obtain the following inequalities:

$$SAC(Y_2)>C(0, Y_2) \quad \Leftrightarrow \quad IC(Y_1)<C(Y_1, Y_2) - C(0, Y_2) \qquad (13)$$

$$\Leftrightarrow \quad \frac{C(\underline{Y}_1,Y_2)-C(0,Y_2)}{\underline{Y}_1} > \frac{\partial C(Y_1,Y_2)}{\partial Y_1}\Big|_{Y_1=\underline{Y}_1}.$$

That is to say, in the case where the product-specific scale economies exist, the definitions given above represent both the upper limit of stand-alone cost and the lower limit of incremental cost[9]. On the other hand, in the case where the product-specific scale diseconomies exist, the reverse holds.

6. The result of the analysis of the stand-alone cost and the incremental cost

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[9] Several studies have so far been carried out on the Japanese local telecommunications industry. See Asai and Nemoto (2001), Asai (2001) for example. To sum up, the economies of scale of the telephone service are quite small, or do not exist in the urban areas, while those of the leased circuit service are still large. It follows that Palmer's method appropriately represents the stand-alone cost of the leased circuit service and the incremental cost of the telephone service (see Eq. (11)) and, on the other hand, confines the upper limit of stand-alone cost of the telephone service and the lower limit of the incremental cost of the leased circuit service (see Eq. (12)).

In this section, we will analyze the result of the analysis from the viewpoints of cross-section and time-series. Tables 3 and 4 represent the stand-alone costs and the incremental costs of the telephone service and the leased circuit service in 1992 and 1997 respectively. Furthermore, Figs. 2 and 3 graphically display Tables 3 and 4. The observations can be summarized as follows[10].

<Tables 3 and 4>

<Figs. 2 and 3>

Observation 1. The costs of the larger regional offices operating in the metropolitan areas are lower than those of the smaller regional offices operating in the rural areas with regard to both the telephone service and the leased circuit service.

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[10] The statistical significances of the costs of the telephone service are high while, in particular, the incremental costs of the leased circuit service are low. One reason for this is that the first-term coefficient of the leased circuit service is not statistically significant. However, there are other reasons: first, the incremental cost is defined as the total cost minus stand-alone cost and therefore must be calculated with more estimates than the stand-alone cost; second, and probably foremost, the estimated figures of the incremental cost themselves are really small.

To take Table 4 for example, the average stand-alone cost and the average incremental cost of the telephone service of the larger regional offices (Tokyo, Kanto, Tokai, and Kansai) in 1997 are 108.4 and 95.7 respectively, while for the other smaller regional offices the figures are139.2 and 133.5. Similarly, the average stand-alone cost and the average incremental cost of the leased circuit service of the larger regional offices are 19.3 and 1.7 respectively, while for the smaller regional offices they are 22.3 and 11.3.

Observation 2. The cost gap of the telephone service is smaller than that of the leased circuit between the eleven NTT's regional offices.

To take Table 4 for example, the coefficient of variation of the average stand-alone cost of the telephone service in 1997 is 0.126, while for the leased circuit service the figure is 0.236. Similarly, the coefficient of variation of the average incremental cost of the telephone service is 0.167, while for the leased circuit service it is 0.694.

Observation 3. The costs of the telephone service have not decreased while those of the leased circuit service have decreased significantly.

To compare Tables 3 and 4, the rate of increase of the average stand-alone cost and the average incremental cost of the telephone service throughout 1992-1997 are 0.5% and 5% respectively, while for the leased circuit service the figures are -65% and –68%. This seems to reflect the fact that the growth rate of the telephone service decreased in the years after 1995 while that of the leased circuit service has consistently risen.

Observation 4. The difference between the average stand-alone cost and the average incremental cost of the telephone service is smaller than that of the leased circuit service.

To take Table 4 for example, the ratio of the average incremental cost to the average stand-alone cost of the telephone service in 1997 is 92%, while for the leased circuit service it is 25%. One of the reasons for this is that since it does not need expensive switchboards and feeder plants for an incumbent company to additionally provide the leased circuit service.

7. Some policy implications of the result of the analysis

The number of samples for the estimation is quite limited, and some estimated variables are not significant. Although it is necessary to be concerned about the reliability of the result for this reason, the following points can be made as far as the implications for telecommunications policy are concerned.

The regional gap of costs of the leased circuit service is larger than that of the telephone service. This reason must be investigated from not only an economic point of view but also a technical one. One possible reason is that the number of residential users exceeds that of business users in the telephone service, while the large-volume business users mainly purchase the leased circuit service and therefore the regional gap of the demand density of the leased circuit service is quite large. In addition to this, due to the progress of the multiplexing technology of network, the average cost of the leased circuit service has been drastically decreasing. Since this paper has supposed that the output of leased circuit is represented as the corresponding number of telephone lines, which means that the capacity of the leased circuit facilities is adequately taken into consideration, the regional gap of the demand density of the leased circuit service leads to the large inequality of the average costs. The demand for the leased circuit service is currently expanding nationally with the rapid spread of the Internet. It seems, however, that the regional gap of the demand density of the leased circuit service will persist at least for a while.

The Japanese government is now promoting the nationwide construction of the high-speed and broadband network as a part of the 'Information Technology (IT) Basic Strategy'. It is important to note that such a high speed and broadband network is also using the same multiplexing technology as adopted by the leased circuit service. Although there is a controversy about whether to include the high-speed and broadband service in the universal service policy, the analysis of this paper can be interpreted to show that the construction of the high-speed and broadband network will enlarge the different costs in each region of the next-generation service. It follows from what has been said that the universal service policy is still important in that the different costs in each region continue to be a big issue towards the realization of broadband society of the next generation.

8. Conclusion

This paper, first, estimated the cost function of the Japanese local telecommunications and, second, calculated the stand-alone costs and the incremental costs of the telephone service and the leased circuit service respectively. Based on these results, we went on to investigate the different costs in each region. Finally, we examined the policy implications from our empirical result. Some problems have been left unanswered. First, Palmer's method just limits the range of stand-alone cost and incremental cost unless the product-specific economies of scope are constant. In this respect, what we did is the approximate comparison of the different costs in each region. Second, the purpose of this paper is to compare the cost structures between POTS and other advanced services. However, 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, but we understand the limitation of such an indirect approach, and therefore we have to wait for more data to be collected. We are fully aware of the questions stated above and consider them to be subjects for future research.

References

Asai, S., Nemoto, J., 2001. Productivity Growth and Technical Change in Japanese Telecommunications Services, the JCER Economic Journal 43, 1-17 (in Japanese).

Asai, S., 2001. On the Economies of Scale and Scope in the Japanese Local Telecommunications, The Journal of Gifu Keizai University 35.1, 125-136 (in Japanese).

Bohlin, E., 1997. Restructuring Japan's Telecommunications, Telecommunications Policy 21.2, 79-84.

Hayashi, K., Fuke, H., 2000. Telecommunications Industries, in: Y. Toyama, et al., (Eds.), Public Utility Industries in Japan, Michigan State University Papers, pp. 133-145.

Mackenzie, D.J., 1997. Econometric Cost Structure Estimates for Cellular Telephony in the United States, Journal of Regulatory Economics 12, 147-157.

Nakajima, T., Hatta, K., 1993, The Economic Analysis of the Japanese Telecommunications, Review of Posts and Telecommunications 4, 20-40 (in Japanese).

Oniki, H., Oum, H., Stevenson, R., Zhang, Y., 1994. The Productivity Effects of the Liberalization of Japanese Telecommunications Policy, The Journal of Productivity Analysis 5, 63-79.

Palmer, K, 1991. Using an Upper Bound on Stand-alone Cost in Tests of Cross Subsidy, Economics letters 35, 457-460.

Palmer, K, 1992. A Test for Cross Subsidies in Local Telephone Rates: Do Business Customers Subsidize Residential Customers?, RAND Journal of Economics 23, 415-431.

Röller, L.H, 1990. Modeling Cost Structure: The Bell System Revisited, Applied Economics 22, 1661-1674.

Pulley, L.B., Braustein, Y.M., 1992. A Composite Cost Function for Multiproduct Firms with an Application to Economies in Banking, Review of Economics and Statistics 74, 221-230.

Sueyoshi, T., 1996. Divestiture of Nippon Telegraph and Telephone, Management Science 42, 1326-1351.

Tachibanaki, T., Irie, H., 1994. The Economic Analysis of the Privatization of the Japanese Telecommunications, in: T. Hayashi, (Ed.)., Public Regulation and Industries Vol.3: Telecommunications, NTT Press (in Japanese).

Toft, A., T. Bjorndal, 1997. The Structure of Production in the Norwegian Fish-Processing Industry, Journal of Productivity Analysis 8, 247-267.

Tsuji, M., 2000. Deregulation in the Japanese Telecommunications Market: New Regulatory Schemes, in: M. Kagami and M. Tsuji, (Eds.), Privatization, Deregulation and Economic Efficiency, Edward Elgar, pp. 163-186.

Table 1. The average outputs of telephone and leased circuit

The cross-section											
	Hokkaido	Tohoku	Tokyo	Kanto	Shinetsu	Tokai	Hokuriku	Kansai	Chugoku	Shikoku	Kyushu	Average
Telephone	154631.5	214683.7	535629.3	734181.3	101065.8	369547.0	71387.5	621526.8	198522.3	104015.2	359424.5	314965.0
Leased circuit	48739.0	98471.5	464121.7	271995.8	43679.0	169701.7	40876.5	290096.7	83777.7	39945.5	128985.2	152762.7
The time-series												
	1992	1993	1994	1995	1996	1997	Average					
Telephone	313964.5	318977.4	328146.0	321331.6	312783.2	294587.4	314965.0					
Leased circuit	129363.5	132089.6	138345.2	145364.5	170082.0	201331.7	152762.7					

Note. Units: telephone, 1000hours; leased circuit, the corresponding number of telephone lines

Table 2. The result of the estimation

Variable, Coefficinent (Standard error)	
α_0 -0.7229 (1.7168)	ρ_{1K} -0.0265 (0.0096) **
α_L 0.0811 (0.0981)	ρ_{2M} -0.0192 (0.0051) **
α_M 0.8475 (0.0654)**	ρ_{2K} 0.0534 (0.0088) **
β_{LM} -0.1210 (0.0159) **	λ_L -0.0097 (0.0030) **
β_{LK} 0.0379 (0.0412)	λ_M 0.0182 (0.0014) **
β_{MK} -0.0063 (0.0155)	θ_1 0.0135 (0.0101)
γ_1 1.2868 (0.1372) **	θ_2 -0.0028 (0.0089)
γ_2 0.1669 (0.1706)	τ_t -0.0749 (0.0474)
δ_{12} -0.0219 (0.0126)*	τ_{tt} 0.0118 (0.0039) **
ρ_{1M} 0.0304 (0.0054) **	δ -0.0096 (0.0017) **

Note 1. Adjusted R^2: the cost function, 0.995; the labor share equation, 0.776; the fuel share equation, 0.929

Note 2. Standard error is heteroscedastic consistent standard error.

Note 3. **statistical significance at the 5% level, *statistical significance at the 10% level

Table 3. The standalone and incremental costs in 1992

	Stand-alone costs				Incremental costs				Total cost
	Telephone		Leased circuit		Telephone		Leased circuit		
	Cost	Average cost	Cost	Average cost	Cost	Average cost	Cost	Average cost	
Hokkaido	2161.5**	136.1**	341.3*	80.3*	1981.4**	124.8**	161.2	37.9	2322.8**
Tohoku	2733.4**	132.6**	472.4*	58.5*	2456.3*	119.2*	195.2	24.2	2928.7**
Tokyo	5968.1*	107.0*	1325	32.5	4890.3*	87.6*	247.2	6.1	6215.3*
Kanto	7119.0*	100.1*	1461.2*	65.0*	5947.0*	84.0*	316.2	14.1	7435.2*
Shinetsu	1385.7**	142.9**	222.8*	60.7*	1292.3**	133.3**	129.4	35.2	1515.0**
Tokai	4266.3**	116.8**	817.5*	59.7*	3681.4**	100.8**	232.6	17	4498.9**
Hokuriku	1043.4**	147.5**	166.4*	47.7*	982.2**	138.9**	105.2	30.2	1148.6**
Kansai	6458.9*	102.8*	1313.3*	53.9*	5401.4*	86.0*	255.8	10.5	6714.7*
Chugoku	2869.9**	143.8**	481.3*	66.6*	2588.3**	129.7**	199.7	27.6	3069.6**
Shikoku	1498.1**	144.8**	230.5*	69.5*	1396.6**	134.9**	128.9	38.9	1627.0**
Kyusyu	4487.8**	126.4**	798.0*	72.7*	3957.5**	111.5**	267.7	24.4	4755.5**
Urban average	5953.1	106.7	1229.3	52.8	4980.0	89.6	263.0	11.9	6216.0
Rural average	2311.4	139.2	387.5	65.1	2093.5	127.5	169.6	31.2	2481.0
Total average	3635.6	127.3	693.6	60.6	3143.2	113.7	203.6	24.2	3839.2
Coefficient of variation	0.594	0.141	0.696	0.213	0.553	0.184	0.329	0.461	0.579

Note 1. Units: stand-alone cost and incremental cost, and total cost: 100 million yen; average cost of telephone: 10000 yen/1000 hours; average cost of leased circuit: 10000 yen/the corresponding number of telephone lines

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

Note 3. Urban areas are Tokyo, Kanto, Tokai, and Kansai.

Table 4. The stand-alone and incremental costs in 1997

	Stand-alone costs				Incremental costs				Total cost
	Telephone		Leased circuit		Telephone		Leased circuit		
	Cost	Average cost	Cost	Average cost	Cost	Average cost	Cost	Average cost	
Hokkaido	1939.1**	134.5**	157.4	25.6	1863.7**	129.3**	82.1	13.3	2021.2**
Tohoku	2914.4**	139.1**	283.4	22.6	2731.7**	130.4**	100.7	8	3015.1**
Tokyo	5121.7**	107.9**	685	11.4	4472.4**	94.2**	35.7	0.6	5157.4**
Kanto	7567.3**	106.8**	985.9	26.4	6628.6**	93.5**	47.2	1.3	7614.5**
Shinetsu	1391.3**	140.3**	111.3	20.8	1354.3**	136.5**	74.4	13.9	1465.6**
Tokai	3972.4**	115.2**	497.9	18.9	3565.1**	103.4**	90.6	3.4	4063.0**
Hokuriku	950.2**	142.8**	75.3	14.8	939.0**	141.1**	64.1	12.6	1014.3**
Kansai	5937.2**	103.6**	750.4	20.6	5240.6**	91.5**	53.8	1.5	5991.0**
Chugoku	2662.4**	144.7**	242.5	23.1	2520.6**	137.0**	100.6	9.6	2763.0**
Shikoku	1386.3**	141.2**	108.4	20.7	1354.8**	138.0**	76.9	14.7	1463.2**
Kyusyu	4459.7**	132.1**	465.8	28.7	4112.8**	121.9**	118.9	7.3	4578.6**
Urban average	5649.7	108.4	729.8	19.3	4976.7	95.7	56.8	1.7	5706.5
Rural average	2243.3	139.2	206.3	22.3	2125.3	133.5	88.2	11.3	2331.6
Total average	3482	128	396.7	21.2	3162.1	119.7	76.8	7.8	3558.8
Coefficient of variation	0.61	0.126	0.77	0.236	0.573	0.167	0.329	0.694	0.594

Note 1. Units: standalone cost and incremental cost, and total cost: 100 million yen; average cost of telephone: 10000 yen/1000 hours; average cost of leased circuit: 10000 yen/the corresponding number of telephone lines

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

Note 3. Urban areas are Tokyo, Kanto, Tokai, and Kansai.

Fig. 1. Eleven NTT's regional offices

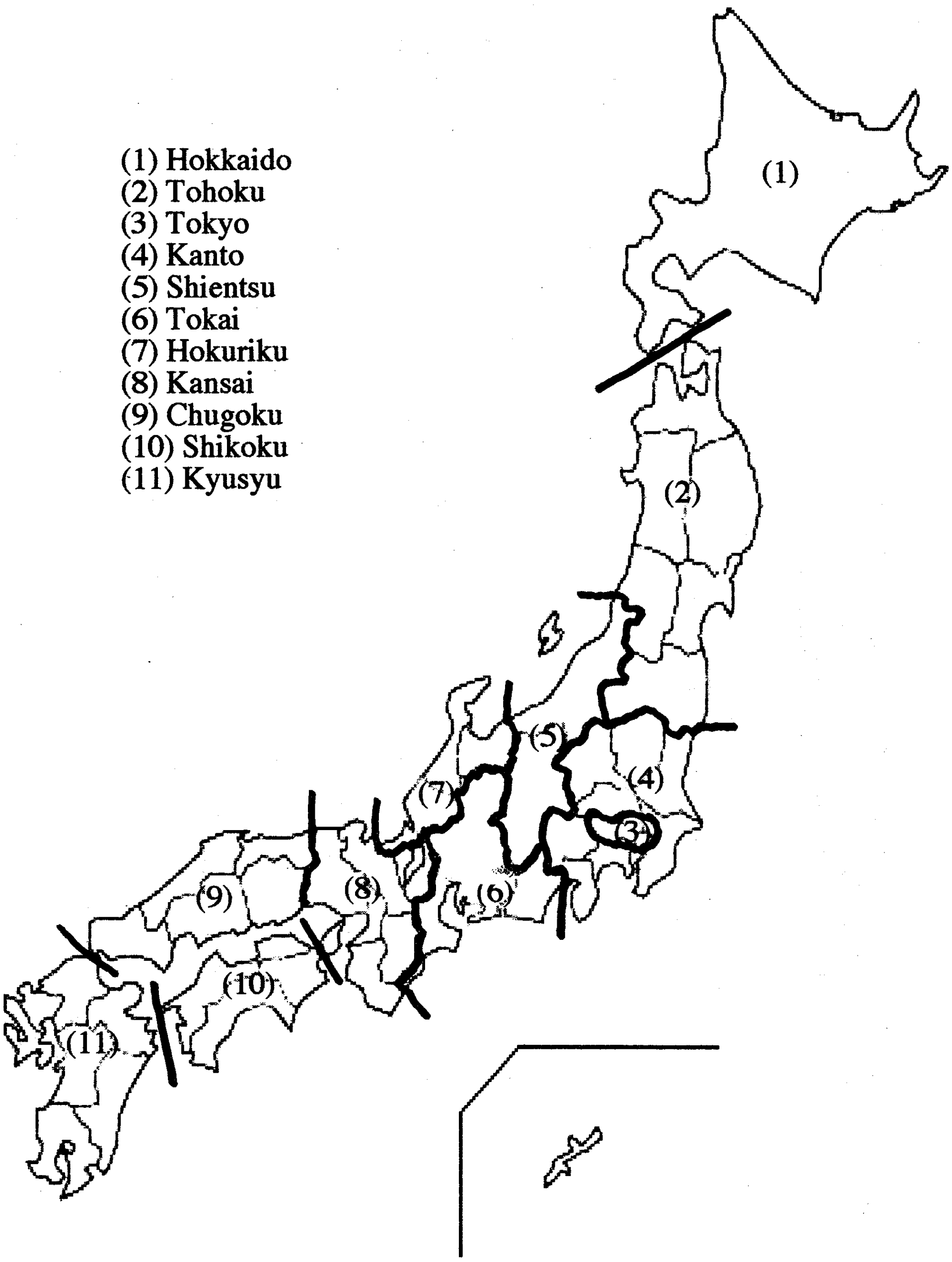
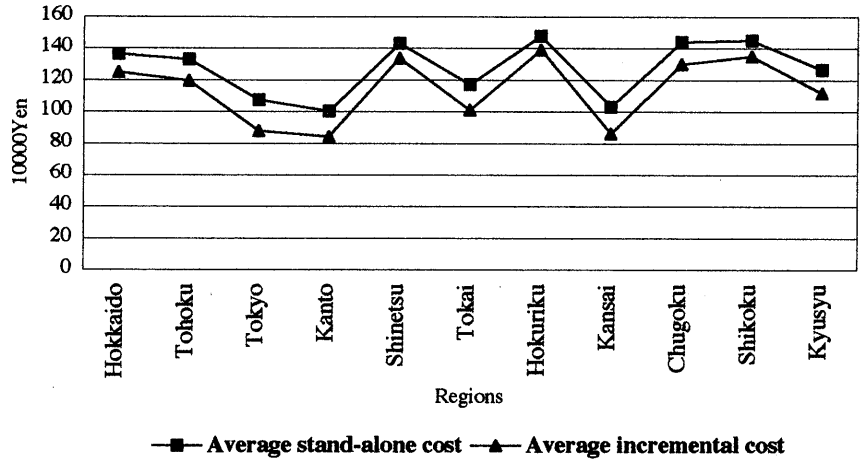


Fig. 2. The stand-alone and incremental costs in 1992

(a) The telephone service in 1992



(b) The leased circuit service in 1992

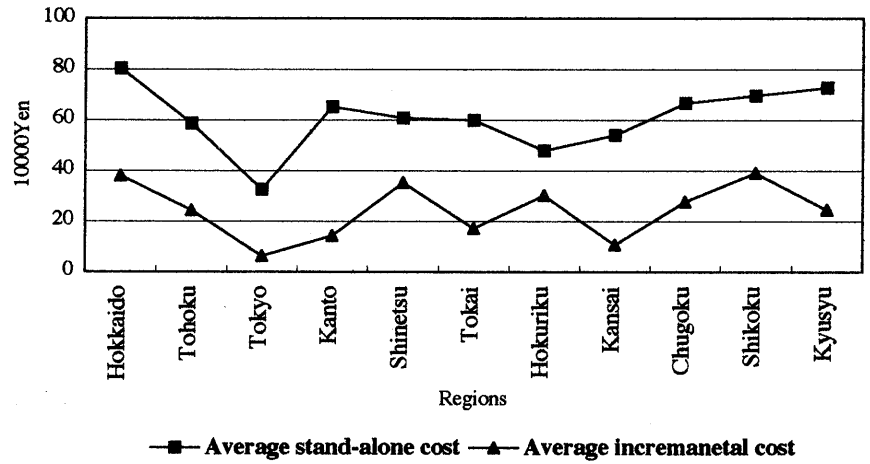


Fig. 3. The stand-alone and incremental costs in 1997