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The Productivity Analysis of Postal Services
－Global Comparison of the Technical Efficiency and the Total Factor Productivity－

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The Productivity Analysis of Postal Services[***]

-Global Comparison of the Technical Efficiency and the Total Factor Productivity-

郵便事業の生産性分析―技術効率性と全要素生産性の国際比較―）

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要約］

1　日本の郵便事業は平成15 (2003) 年に信書送達分野への民間参入が認められるとともに、「国営の新たな公社」によって郵便サービスが提供されることとなっており、企業形態に近い公社は民間事業者との競争の中で「生産性」、「効率性」などの経営指標を重視することが求められることが予想される。本稿ではこのような問題意識のもとで生産性、効率性の国際比較を行い、特に効率性に影響を与える要因について分析を行った。

2　最初に1991年から97年における米国、欧州17か国、オーストラリア、日本の全20郵便事業体を対象にDEA（包絡分析）法により技術効率性および全要素生産性を計測した。郵便事業の生産物を「取扱郵便物数」または「実質郵便業務収入」、生産要素を「郵便職員数」、「郵便局数」、「業務用車両台数」として計測したところ、サンプル中では日本および米国は最も効率的な事業運営を行ってきたことが分かった。

3　技術効率性の水準に影響を与える要因についてパネルデータによる分析を行ったところ、「国民1人当りの郵便物数」の動向が効率性に与える影響が大きいことが示された。また、欧州諸国の90年代における事業の公社化など経営形態の変革も効率性にプラスの影響を及ぼしたことを示唆する結果となった。ただし、本稿において計測・分析を行った効率性は経営形態や事業内容が異なる事業体を対象とした相対的な概念であることに留意する必要がある。

[***] 本稿における見解は全て執筆者個人のものであり、総務省、郵政事業庁ならびに筆者達が属する機関の公式見解を示すものではない。

The Productivity Analysis of Postal Services[1,2]

Global Comparison of the Technical Efficiency and the Total Factor Productivity

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1. Introduction

In Japan, the Postal Services Agency[3] has provided monopolistic postal services for more than one hundred years. However, the letter-post delivery will be opened to the private sector in 2003, and the Agency will become a "new state-run corporation" with a flexible management. Postal administrations in many industrialized countries will also face diminishing reserved areas and increasing competition with newcomers in the liberalized market. For postal services to fulfill their universal service obligation (USO), the establishment of a sound management system by maintaining high efficiency and productivity is a key issue.

The objective of this paper is to measure and analyze the efficiency and productivity of postal services in advanced industrialized countries in Europe, America and Asia. Section 2 concerning postal services operation in Japan will outline both outputs and inputs based on the number of mail items, postal employees, and post offices. Section 3 will summarize the basic

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1 The content of this paper is solely the authors' opinion and does not reflect official opinions of the Ministry of Public Management, Home Affairs, Posts and Telecommunications, the Postal Services Agency, and the organizations to which the authors belong.

2 We thank Frank Wolak as a discussant in the Conference on Postal and Delivery Economics (9th CPDE) in Sorrento, Italy. We also thank Michael A.Crew and Paul R.Kleindorfer for giving us beneficial comments to a draft.

3 Formerly the Ministry of Posts and Telecommunications (MPT)

concept towards efficiency and productivity, and elaborate on the efficiency measurement method known as Data Envelopment Analysis (DEA). Section 4 will measure efficiency and productivity derived from postal statistics obtained from major industrialized countries utilizing DEA. Furthermore, the impact of postal factors (e.g. collection, delivery and transport) and transitions in management structure on the measured efficiency will be covered as well. Section 5 is the conclusion.

2. Current State of Japan's Postal Service

2.1 Environmental Shifts in Japan's Postal Services

Article 1 of Postal Law, which is the basis for Japan's postal operations, states, "The objective of postal service is to enhance public welfare by fairly providing postal services with the lowest possible rate on a universal basis." Based on this policy, the MPT (currently the Postal Services Agency) has provided postal universal service since 1871. The MPT clarified Japan's postal universal services more specifically as "To deliver letter-post items and parcels accepted through post boxes or post offices throughout the nation, with the lowest possible price and on a universal basis to each doorstep[4]." In 2003, Japan's postal operation is scheduled to shift from the Postal Services Agency to a "new state-run corporation". The corporation will be required to carry the burden of the Universal Service Obligation (USO). In order to abide by the philosophy of USO in midst of fierce competition with private sectors, the public corporation is expected to focus on increasing operational efficiency and productivity to maintain an affordable postal rate.

2.2 Outputs and Inputs for Postal Service

This section will show actual data related to outputs and inputs in postal services. In the following analysis, outputs are

[4] See "The Research and Study on Universal Service in Postal Services" issued by the Institute for Posts and Telecommunications Policy and the Ministry of Posts and Telecommunications in December 2000. Full report can be obtained at website: www.iptp.go.jp/ (Japanese only).

represented by the "number of handled mail items[5]," whereas postal inputs are the "number of postal staff" responsible for handling postal tasks and the "number of post offices[6]" that are the postal operation's largest tangible asset. The transitions in these three factors are shown in Figure 1. With regards to postal staff, the increase rate has been less than 1% in the recent 20 years and the number has been decreasing in the past 6 years. Furthermore, placement of post offices is based on population shifts; however, the growth rate in facilities is also less than 1% in the past 20 years, similar to the rate of employee increase[7]. Contrarily, the number of mail is on a consistent rise with only three decreases in years 1976, 1981 and 1994. These decreases were largely attributed to rate increases in standard mail such as the First-class (letters) and the Second-class (postcards) mail.

When creating simple productivity indices based on calculations of postal outputs divided by the number of employees (ratio of mail handled per employee) and outputs divided by post offices (ratio of mail per office), both indices show consistent upward growth over the past forty years. Through these ratios, we can observe that the productivity increase in late 1990s has not been significant compared to in the 1980s. In any case these data is insufficient in determining whether Japan's postal services have been operating 'efficiently' or not. We will proceed into further measurement and analysis of productivity and efficiency utilizing actual output and input data in next two sections.

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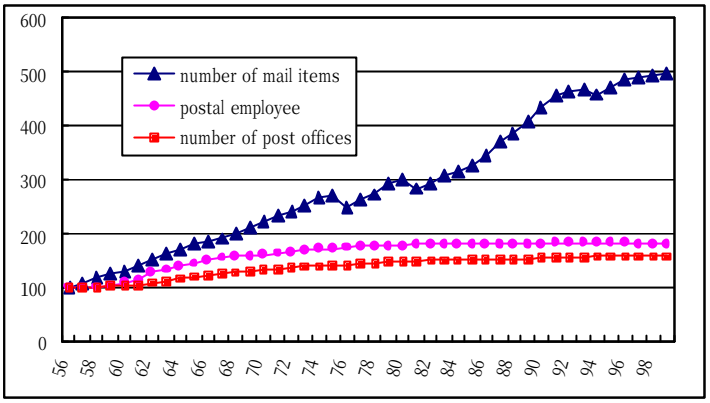
5 We substituted the number of accepted mail for the number of handled mail, which is available as the product of postal services in Japan.

6 Only some portion of the postal facility should be applied to postal services because Japan's post office provides the three separate operations – postal service, savings and insurance. Postal operations are also partly served by common employees in headquarters and local facilities, so both the number of employees providing postal service and a certain ratio of common employees should be considered as an investment factor.

7 Contributions from part-time employees and outsourcing of collection and delivery services are not included in the statistical data. Furthermore, we should consider the actual amount of capital stock instead of simply utilizing the number of postal facilities as an investment factor.

Figure 1: Number of Japan's Mail Items, Postal Employee, and Post Offices (1956=100)



(Data Source) Postal Services Agency

3. The Measurement Methodology of Efficiency and Productivity

3.1 Efficiency

3.1.1 Technical Efficiency and Allocative Efficiency

According to Farrell [1957], total efficiency can be decomposed into two parts: Technical Efficiency (TE) and Allocative Efficiency (AE). The TE is the capability to invest minimum inputs upon the given outputs or to produce maximum outputs upon the given inputs, and the AE is the capability to optimize inputs based on a given input / output prices and a given production function. The product of TE and AE is referred to as the Economic Efficiency (EE). In this paper we will focus mainly on the TE. There are two concepts to TE – one is the Output-Oriented approach, which works toward gaining the maximum volume of product with a given amount of investment and the other is the Input-Oriented approach, which aims at gaining a certain volume of product with minimal investment. We applied the Input-Oriented model in measuring efficiency for this analysis. This is based on premise that while output variables such as the number of mail is given as demand market factors, input variables

such as the number of employees and post offices can be controlled by the postal administration to accommodate environmental changes.

3.1.2 DEA for TE estimation

As methods to measure TE, non-parametric methods such as DEA (Data Envelopment Analysis), which do not assume specific production or cost function forms, are used widely. In this method, TE is measured first by setting a standard, which is called the 'efficient frontier,' derived from highly efficient units based on actual data and then taking the distance from the frontier. The DEA's key characteristic is the capability to measure by extracting efficiency, the efficiency frontier can be set using only volume information. However, we should note that the calculated efficiency in this method is a relative concept derived from the most efficient units included in the sample. The DEA Method is also incapable of eliminating statistical discrepancies (noise)[8].

3.2 Productivity

Productivity is represented by the ratio between total product (output) and amount of investment (input) made during the same timeframe. We should keep in mind that productivity is not identical to the aforementioned TE. While TE is represented by distance from the efficient frontier, making the efficiency frontier its maximum limit; productivity fluctuates depending on factors such as shifts in supply and demand structure, thus it is possible to improve productivity even when technically efficient operation is already accomplished.

The Productivity Index can be measured as Total Factor Productivity (TFP) or Partial Factor Productivity (PFP) by altering the variables utilized in the input factor. As can be seen in utilization of the labor productivity in a labor-intensive industry such as postal

[8] SF (Stochastic Frontier) Method is a procedure which assumes a specific stochastic production (cost) function and measures the TE by decomposing the distance from the efficient frontier into measurement error and inefficiency. We can decompose error and inefficiency, which is difficult using the DEA Method.

operations that have significant human input[9], PFP provides significant implications as a management index. However, there is no guarantee that the direction of TFP and PFP will be identical. It can be said that TFP is a relatively better indicator of productivity compared to PFP, as the overall investment factor can be evaluated comprehensively.

3.3 Relation Between TE and TFP

With regards to the relationship between TE and TFP, we can explain it based on the framework of the Malmquist Productivity Index (MPI) structured by Färe, Grosskopf, Norris and Zhang[1994]. We will explain the DEA method in Figure2. When we have three units (A, B, and C), both F_t and F_{t+1} are the efficiency production frontier derived from sample units at term t and t+1, respectively. TE is calculated by computing the distance between the efficiency frontier and each of the production sets. As for unit At in Figure2, if investment and production set (x_t, y_t) in term "t" were to shift to those in term "t+1" , namely (x_{t+1}, y_{t+1}), the changing rate of TE will be represented by equation (1),

$$TE_i\,(y_t, x_t, y_{t+1}, x_{t+1}) = \left[\frac{d_i^{t+1}(x_{t+1}, y_{t+1})}{d_i^{t}(x_t, y_t)} \right] \qquad \ldots\ldots(1)$$

where d denotes the difference from the efficiency frontier in term t, namely the TE in t, and i denotes the Input-Oriented approach in section3.1.1.

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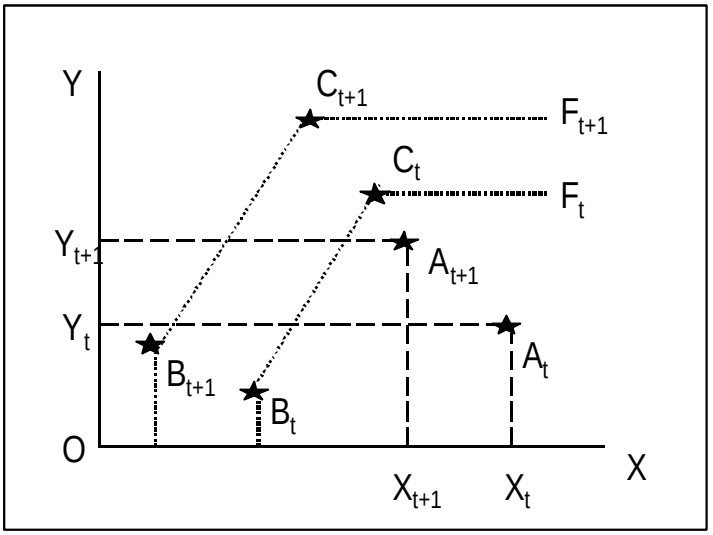
[9] According to Stiglitz [1997], "By measuring the labor productivity, one can actually know the productivity of the entire postal operation due to the fact that personnel costs account for 80% of the USPS's total expenses". The number of mails delivered per employee is utilized as the productivity. Based on this measurement, the rate of productivity in postal operations between years 1975 – 1980 has exceeded those seen in private sectors.

Figure2: TE and MPI for the DEA analysis



Whereas the changing rate of MPI between term "t" and "t+1" is calculated based on geometric mean of MPI in terms "t" and "t+1".

$$M_i(y_t, x_t, y_{t+1}, x_{t+1}) = [\, M_i^t(y_t, x_t, y_{t+1}, x_{t+1}) * M_i^{t+1}(y_t, x_t, y_{t+1}, x_{t+1}) \,]^{1/2}$$
$$= \left[\frac{d_i^t(x_{t+1}, y_{t+1})}{d_i^t(x_t, y_t)} * \frac{d_i^{t+1}(x_{t+1}, y_{t+1})}{d_i^{t+1}(x_t, y_t)} \right]^{1/2} \quad \ldots\ldots(2)$$

In assuming technological inefficiencies in terms "t" and "t+1"(namely, $TE \neq 1$), equation (2) can be modified to equation (3) and here productivity index can be decomposed into fluctuation rate of TE and the other part.

$$M_i(y_t, x_t, y_{t+1}, x_{t+1}) = \left[\frac{d_i^{t+1}(x_{t+1}, y_{t+1})}{d_i^t(x_t, y_t)} \right] * \left[\frac{d_i^t(x_{t+1}, y_{t+1})}{d_i^{t+1}(x_{t+1}, y_{t+1})} * \frac{d_i^t(x_t, y_t)}{d_i^{t+1}(x_t, y_t)} \right]^{1/2} \quad \ldots\ldots(3)$$

The second bracket in equation (3) represents the rate of technology fluctuation expressed via the geometric mean of technology in terms "t+1" and "t", respectively. The MPI can be

decomposed into the TE and rate of technology fluctuation under the assumption of technological inefficiency.

4. Econometric Analysis for Technical Efficiency and Total Factor Productivity

4.1 The Outline of the Analysis

In this section, we first will measure the postal administration's TE and Malmquist TFP utilizing the DEA method from major industrialized countries data. Then we will analyze factors that have impact on the estimated TE in the following section. We did not apply the parametric or the stochastic frontier method for estimating the TE because we assumed the deviation from the efficient frontier, which is affected by incidental factors such as weather or random chance, does not have a significant role for postal operations [10]. Postal administrations in 20 major industrialized countries (Australia, Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Japan, Luxemburg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, America, United Kingdom) with retrievable UPU Postal Statistics data during years 1991 – 1997 were chosen as a sample[11]. All output and input data will be standardized by dividing each average in each year. We utilized Tim Coelli's (University of New England) DEAP Version 2.1 as the DEA method software.

4.2 Output and Input for the postal service

Table 1 shows the summary for the category of outputs, inputs, sample term and the number of samples. In each case the number of postal vehicles was utilized as substitution variable for raw

[10] A.Pimenta and S.Lagoa [2000] shows that almost all of the residual variation from the production frontier is due to efficiency effects and not the measurement errors by the SF estimation using the data of 20 OECD countries' postal administrations.

[11] Data not reported in UPU Statistics have been supplemented through information from annual reports issued by respective postal operations. Due to statistical insufficiencies, revenue data utilized as output index are those obtained only after 1993.

material[12] in addition to the number of postal employees and post offices[13] (representative labor and capital variables, respectively).

The number of domestically handled mail items is utilized as the output in case 1. Domestic mail includes letter-post items in addition to value-added delivery items such as registered mail and express mail but does not include parcels or registered items. Multiplying case1's domestically handled mail and the percentage of the population having mail delivered at home produces the postal item delivered to home for case2 output. Depending on the country, there are remote areas where mail is not delivered to home and receivers must pick mails up at facilities or community boxes. Therefore this output can include the "quality" factor of postal services in the products and to consider the standards of service index correlating to the USO[14]. While the ratio in 1997 was at 100% in most countries, Norway and Finland were at 90% and 93% respectively, and Portugal, the United States, Australia and Italy at 99%.

The case 3 output is real postal receipts. We derived this output by taking the SDR-based postal operational income reported in the UPU statistics and converting them in local currency by applying the exchange rate provided, and further applying the Purchasing Power Parity (PPP) rate created by the OECD in US dollars and deflating the figures by the US consumer price index. These measures were taken to ensure unbiased assessment of postal revenue by eliminating the factor of exchange rate fluctuation and deriving consistent currency value. In this case we are able to include postal service factors not included in case 1 or case 2 (anything other than basic mail and other non-postal services) as outputs.

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12 In Japan's postal operations, expense for outsourcing collection and delivery is the largest nonpersonnel expense category. Other major expenses are for part-time workers' wage and equipment-related purchase expense.

13 Postal staff does not include part time staff. Post offices include full-service offices as well as secondary and agency offices.

14 In EU Directive, universal service standard with regards to delivery is stipulated as "providing services of at least 5 days a week and conducting delivery service at least once during the day," and focuses more heavily on frequency of delivery rather than specific area of delivery. In Japan, the delivery to each doorstep is noted as the key criteria for universal service (IPTP and MPT [2000]).

Table1: the Outputs and the Inputs for DEA

	case1	case2	Case3
Technical Efficiency	TE1	TE2	TE3
Output	Domestic letter-post items	Letter-post items delivered to home	Real total postal receipts
Input	Postal employees Post offices Trucks and automobiles		
Sample Term	91-97	91-97	93-97
Samples	140	140	100

4.3 Estimating the Results of Technical Efficiency

Table 2 shows the measured results of TE for each case. All cases revealed an increasing trend as can be seen in the overall TE average of 0.6 in cases 1 and 2 and 0.7 in case 3. Japan and the U.S. were able to achieve TE_{VRS} of 1.0 (Technically Efficient) for all three cases. A decline in efficiency was seen in case 2 compared with in case1 for European countries with low "home delivery percentage". When observing the general result of case 3, it exceeds the average of both cases 1 and 2; however, this difference is likely to be attributed to the impact brought on by output factors (parcels, international mail and non-postal services) not included in the former two cases.

Table2: TE (4 countries or area, total average)

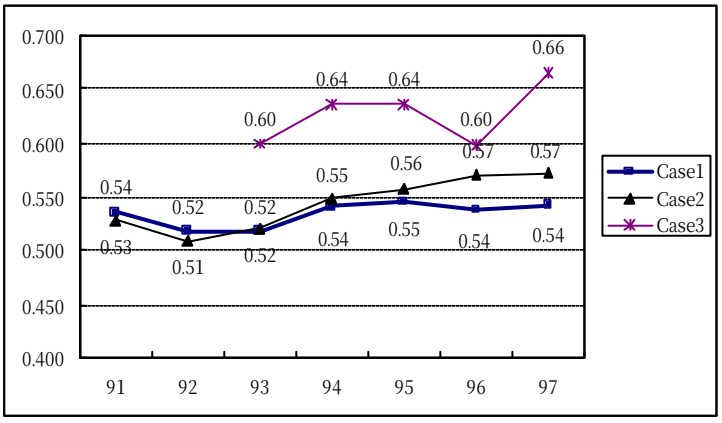
Case1	91	92	93	94	95	96	97
Japan	1.000	1.000	1.000	1.000	1.000	1.000	1.000
US	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Europe	0.566	0.569	0.606	0.605	0.568	0.628	0.621
Australia	0.519	0.543	0.582	0.676	0.665	0.681	0.652
Total	0.607	0.611	0.645	0.648	0.616	0.668	0.661
Case2	91	92	93	94	95	96	97
Japan	1.000	1.000	1.000	1.000	1.000	1.000	1.000
US	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Europe	0.557	0.561	0.601	0.601	0.565	0.627	0.616
Australia	0.461	0.477	0.509	0.587	0.577	0.586	0.646
Total	0.597	0.600	0.636	0.640	0.609	0.662	0.656
Case3	91	92	93	94	95	96	97
Japan			1.000	1.000	1.000	1.000	1.000
US			1.000	1.000	1.000	1.000	1.000
Europe			0.716	0.710	0.694	0.737	0.754
Australia			0.497	0.589	0.696	0.668	0.595
Total			0.733	0.733	0.725	0.759	0.771

(Note) Europe consists of all samples except for Japan, US and Australia.

4.4 The Estimating Results of Total Factor Productivity

In addition to the TE measured above, a Malmquist TFP (average sample) was derived as noted in Figure 3 via utilization of rate of fluctuation in Scale Efficiency (SE) and Technology (TECH). Because the starting value is calculated as a basic value during TFP estimation, information regarding relevant levels is not attainable. Thus, we imposed the assumption that the TFP calculated based on starting value is equivalent to the measured TE[15] value. As a result, the 1994 TFP in cases 1 and 2 reverse positions, however, both continue to proceed with similar trends. Case 3's TFP dropped momentarily in 1996 but overall, similar to the measured TE results, it is anticipated to be at a higher standard compared to the TFP in other cases. See appendix for the estimating results of all countries' TE and TFP in each case.

Figure3: Malmquist TFP (total average)



(Note) TFP in 91(Case1, 2) and TFP in 93(Case3) are identical to the TE in each period.

[15] This TE is calculated by assuming the constant return to scale (CRS) production function; whereas, TE in Table2 is represented as the distance from the variable return to scale(VRS) frontier.

4.5 The Factors That Affect Technical Efficiency

4.5.1 Factors Related to Postal Activities

We analyzed the factors affecting the level of the TE for 20 major postal administrations. Activities of postal services can be characterized as follows[16]: collecting postal items from mail boxes and post offices, transporting mail items that are to be delivered at other regions, and delivering mails that are brought in from other post offices as well as its own collected mails. First of all, we consider such factors concerning postal activities for affecting the TE. These activities are represented by collection, delivery and transportation, which will correspondent to next indicators.

- 'collection'---postal items per households (company)
- 'delivery'---the density of the delivery point
- 'transportation'---the density of transportation network

The more postal items per household (company), or the more the density of the delivery point, the more the efficiency is expected to improve because the postal employees or the post office can handle more postal items at once. On the contrary, the more the density of transportation network, the less the efficiency as the high-density network cause less postal items per transportation. Next, we composed variables from the UPU statistics as the substitution variables of three factors explained earlier. The sign in a bracket means the expected estimation result.

-Postal items per households (company) ---postal items per population (+)

-The density of the delivery point---population per post office (+)

-The density of transportation network ---trucks and automobiles per area (-)

[16] For postal operation the processing activity including sorting dispatching and arriving mails also plays an essential part of postal services. However, we did not apply variables concerning processing activity due to insufficiency of the available data.

4.5.2 The Management Style of Postal Administrations

In conducting a time-series analysis of TE, we now focus on management structure as a controllable variable within a postal operation. There are a variety of management styles in our sample, including privatized operations, public corporations, and state-run operations. For example, the TNT Post Group NV (Netherlands) had already publicly offered a portion of their stock to private sectors in 1989, and Australia turned its state-run business into a public corporation during the same year. During the 1990s, some postal administrations such as Italy (in 1994) and Portugal (in 1992) changed from state-run operational styles to a public corporation or an incorporated company with full government ownership[17].

In the following section, we will further analyze the concept of efficiency through observing the effect such reform had on the TE. The dummy variable is assigned for the year and after the year of management change. This variable will be therefore unchanged when administrations changed their management styles before or after the estimation terms (1991-97). Thus, it must be kept in mind that the purpose of this analysis is to focus on the impact of actual organizational "change" to the efficiency fluctuations.

4.5.3 Panel Data Analysis

We constructed a model to estimate the TE by the three variables concerning the postal activities: postal volumes per population, population per post office, and trucks and automobiles per area, as defined previously, adding the dummy variables of the change of the management style, and the trend variable as substitutions of technical innovation. This model is represented as the equation (4). Here we re-defined the TE as the distance from the 'Super Frontier', which is estimated by using all the pooling data in the sample terms to conduct the time-series estimations. We adopted the TE2 conception for outputs, in which the output is the postal volume delivered to homes, because we could not find the difference from three output indices (postal volume, postal volume delivered to

[17] Other postal ministrations that changed their management style between 1991 and 1997 are France(91), Luxembourg(93), Finland(94), Sweden(94), Germany(95), Denmark(95), Austria(96), and Norway(97).

home and the real postal receipt) in the actual estimation. The inputs are the number of postal staff, post offices, and trucks and automobiles.

$$TE_{it} = b_1 * (Volume/Pop)_{it} + b_2 * (Pop/Post)_{it} + b_3 * (Truck/Area)_{it} + b_4 * (Manage)_{it} + b_5 * (Time) + b_6 * (Time)^2{}_{it} + v_{it}$$
$$v_{it} = a_i + e_{it} \qquad \ldots(4)$$

i=1,2,…20(postal administrations), t=1,2,…7(year)

-TE : the Technical Efficiency
-Volume: postal volume delivered to home
-Pop : population
-Post : the number of post office
-Truck : the number of trucks and automobiles
-Area : area
-Manage : management style dummy(the year after the management change should be 1)
-Time : time(T=1,2...7)
-$(Time)^2$: the squares of time variables
-a : the fixed effect of each postal administration

4.5.4The Estimation Results

Table 3 describes the fixed effect estimations[18,19]. We obtained the expected sign of the three independent variables concerning the postal activities defined earlier, and the magnitude of the postal volume per population variables became relatively greater. Panel1, panel2 and panel3 are the results of the OLS estimation in which the weight of the each decision-making unit is equal, while

[18] The fixed effect model was conducted in the panel data estimation to incorporate unique impacts in respective administration because the differences was observed through management styles as well as actual management policies of each postal operation. The Wu-Hausman test result indicated to apply the fixed effect model for both estimations at 5% or 10% significant level.

[19] We utilized the E-views version 3.1 (Quantitative Micro Software) for panel data estimation. Further details regarding estimation method by E-views can be found in K.Matsuura and C.McKenzie [2001].

Panel4 is the result of the GLS estimation in which the residuals of each unit are adjusted to have the same variances. We applied the GLS, as the heteroscedasticity was obvious from the discrepancy in terms of administration's size and market structure.

Compared with the estimation results of Cohen, Chu, Ferguson and Xenakis [1997], which showed that the more postal volume per population, the more the labor productivity, our estimation results are not inconsistent with their estimation implications although we constructed a model to explain not productivity but technical efficiency. In Pimenta, Santos and Laogoa [2000], population per postal counters and postal volume per post box showed positive effects to the TE by SF method. We adopted slightly different variables from theirs, but the results do not contradict each other.

Table3: The Estimation Results of TE (the Fixed Effect model)

	Panel1	Panel2	Panel3	Panel4
Volume/pop	0.28586 ***	0.28523 ***	0.27632 ***	0.29233 ***
	(0.0430)	(0.0432)	(0.0455)	(0.0063)
Pop/post office	0.15437 ***	0.14801 ***	0.13806 **	0.18518 ***
	(0.0504)	(0.0543)	(0.0606)	(0.0076)
trucks/area	-0.02626 *	-0.02614 *	-0.02680 *	-0.03573 ***
	(0.0137)	(0.0138)	(0.0143)	(0.0532)
management		0.00496	0.00189	0.00181 **
		(0.0155)	(0.0172)	(0.0008)
Time			-0.00430	-0.00357 ***
			(0.0013)	(0.0053)
(Time)*2			0.00070	0.00025 ***
			(0.0013)	(0.0000)
adj R^2	0.96424	0.96397	0.96348	0.99840
Sample	140	140	140	140

(Note) The figures inside bracket are standard error.
Panel1, 2 and 3 are the results of OLS, Panel4 is of GLS estimation.
*** Means significant in 1% significant level, ** in 5%, * in 10%
The technical efficiency is TE2 (postal volume delivered to home)

In panel2 and panel3 the sign of the management change was not significant, although in panel4 it was significantly positive which implies that the change of the management structure affected the improvement of the TE. We had different results because only half of the postal administrations in our samples changed management styles, which will take a long period of time to appear as concrete results of

such change. For the same reason the results of the time variables as the substitution of technological innovation were not clear. We have to study the effect of these variables in the long-term perspective.

5 Conclusions

Facing the minimization or abolition of the reserved areas and increasing competition from private operations, the postal administration must focus on efficiency and productivity to maintain affordable postal rates while continuing to fulfill the universal service obligation (USO). To shed light on this issue, we measured the Technical Efficiency (TE) and the Total Factor Productivity (TFP) by DEA method utilizing data from major industrialized countries, and analyzed factors determining efficiency in postal administrations.

We utilized the number of letter-post items or real total receipts as the output of postal services, and the number of postal staff, post offices and postal automobiles as inputs for applying DEA method. As a result of estimating TE and TFP, we found that both indicators as a sample mean showed moderate increase during 1990s. We introduced three factors concerning postal activities for affecting TE, namely 'postal items per households', 'the density of the delivery point', and 'the density of transportation network'. By using these factors we conducted the factor decomposition of TE and obtained the expected estimation results in panel data estimation. When we analyzed the effect of management structure, we obtained results that can imply that a change of management style improved the efficiency for the postal administrations.

However, we have to bear in mind when reviewing the implications behind TE obtained through these analyses. The TE measured via DEA method is in fact a relative efficiency based on standards compared to the most efficient units among the samples. There were operations thriving in an environment with a complete halt to monopolistic reserved areas as well as those operating in an environment with a higher percentage of reserved areas in letter-post delivery. To compare efficiency between a public postal operation and a commercial one, it is necessary to identify the level of investment factors needed to produce the same level of products under equivalent competition criteria. Although analytic proof of this problem is rather difficult especially in a market with insufficient competition, we need

to conduct more analyses for further understanding of postal efficiency.

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APPENDIX

The Estimating Results of

Technical Efficiency and Total Factor Productivity

Technical Efficiency

Case1

	91	92	93	94	95	96	97
Australia	0.5190	0.5429	0.5820	0.6762	0.6654	0.6814	0.6521
Austria	0.2940	0.2855	0.5367	0.4980	0.3930	0.3729	0.4020
Belgium	0.5600	0.5494	0.5917	0.6360	0.5985	0.6230	0.6274
Denmark	0.3680	0.4041	0.4416	0.4266	0.4194	0.3980	0.4016
Finland	0.3010	0.3284	0.2713	0.3382	0.2865	0.5249	0.5658
France	0.5120	0.5228	0.7554	0.5733	0.5143	0.7015	0.5177
Germany	0.3050	0.3453	0.3283	0.3464	0.3370	0.4109	0.4413
Greece	0.6720	0.7580	0.6693	0.6747	0.7374	0.7750	0.7099
Ireland	0.3160	0.3296	0.3283	0.3516	0.2334	0.3712	0.3875
Italy	0.6780	0.4577	0.5071	0.4594	0.4038	0.4511	0.4051
Japan	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Luxembourg	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Netherlands	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Norway	0.8470	0.9037	0.8893	0.8439	0.7072	0.8218	0.8637
Portugal	0.3700	0.3841	0.3591	0.3839	0.3393	0.3298	0.3186
Spain	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Sweden	0.5780	0.5774	0.7200	0.8201	0.7922	0.7875	0.7804
Switzerland	0.4200	0.4263	0.5009	0.5275	0.5006	0.6873	0.7216
USA	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Great Britain	0.3960	0.4031	0.4112	0.3993	0.4009	0.4289	0.4212
mean	0.6068	0.6109	0.6446	0.6478	0.6165	0.6683	0.6608

Total Factor Productivity

Case1

	91	92	93	94	95	96	97
Australia	0.5020	0.5085	0.5441	0.6693	0.6960	0.6828	0.6616
Austria	0.2670	0.2454	0.4336	0.4592	0.4132	0.3095	0.3398
Belgium	0.5370	0.5413	0.5196	0.5617	0.5359	0.5236	0.5283
Denmark	0.3330	0.3586	0.3429	0.3295	0.3163	0.3084	0.3207
Finland	0.2300	0.2374	0.1847	0.2768	0.2397	0.4667	0.4817
France	0.4380	0.4433	0.5182	0.4518	0.4211	0.4615	0.4214
Germany	0.3040	0.3444	0.3145	0.3324	0.3603	0.3744	0.4002
Greece	0.2960	0.3022	0.2786	0.2839	0.3041	0.3202	0.3026
Ireland	0.2390	0.2196	0.2190	0.2310	0.2306	0.2292	0.2452
Italy	0.6100	0.4307	0.4264	0.3944	0.3506	0.3713	0.3316
Japan	1.0000	0.9840	0.9043	0.9007	0.9340	0.8864	0.8722
Luxembourg	0.5690	0.3647	0.3892	0.3763	0.3477	0.3269	0.3301
Netherlands	1.0000	1.0460	0.9132	0.9899	1.5808	0.9611	0.9698
Norway	0.7720	0.7782	0.7097	0.6707	0.5788	0.6534	0.7142
Portugal	0.2660	0.2676	0.2764	0.2952	0.2749	0.2581	0.2663
Spain	1.0000	0.9410	0.8036	0.8221	0.8048	0.7734	0.7557
Sweden	0.5560	0.5516	0.6039	0.7054	0.7075	0.6439	0.6426
Switzerland	0.4070	0.4005	0.4726	0.4990	0.6562	0.6090	0.6400
USA	1.0000	0.9810	0.9035	0.8845	0.8668	0.8833	0.8966
Great Britain	0.3960	0.4047	0.3877	0.3900	0.4107	0.3865	0.3764
mean	0.5361	0.5175	0.5073	0.5262	0.5515	0.5215	0.5249

Technical Efficiency

Case2

	91	92	93	94	95	96	97
Australia	0.4610	0.4767	0.5086	0.5874	0.5769	0.5861	0.6459
Austria	0.2880	0.2762	0.5342	0.4941	0.3898	0.3735	0.4004
Belgium	0.5660	0.5507	0.5964	0.6406	0.6015	0.6322	0.6303
Denmark	0.3750	0.4069	0.4455	0.4308	0.4226	0.4095	0.4046
Finland	0.3000	0.3273	0.2700	0.3348	0.2705	0.4908	0.5320
France	0.5140	0.5279	0.7623	0.5793	0.5214	0.7174	0.5230
Germany	0.3090	0.3464	0.3315	0.3501	0.3413	0.4266	0.4480
Greece	0.6720	0.7580	0.6724	0.6737	0.7391	0.7753	0.7101
Ireland	0.3190	0.3318	0.3294	0.3525	0.2323	0.3756	0.3891
Italy	0.5990	0.4097	0.4577	0.4581	0.4054	0.4468	0.4008
Japan	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Luxembourg	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Netherlands	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Norway	0.7780	0.8325	0.8141	0.7734	0.6551	0.7527	0.7896
Portugal	0.3640	0.3782	0.3521	0.3771	0.3379	0.3254	0.3140
Spain	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Sweden	0.5870	0.5782	0.7227	0.8160	0.7874	0.7961	0.7786
Switzerland	0.3980	0.3988	0.5077	0.5341	0.5010	0.7013	0.7294
USA	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Great Britain	0.4030	0.4062	0.4148	0.4027	0.4068	0.4405	0.4251
mean	0.5967	0.6003	0.6360	0.6402	0.6094	0.6625	0.6560

Total Factor Productivity

Case2

	91	92	93	94	95	96	97
Australia	0.4450	0.4463	0.4749	0.5780	0.5953	0.5917	0.6568
Austria	0.2620	0.2387	0.4342	0.4580	0.4141	0.3143	0.3382
Belgium	0.5430	0.5408	0.5214	0.5615	0.5368	0.5293	0.5250
Denmark	0.3410	0.3628	0.3469	0.3326	0.3197	0.3158	0.3228
Finland	0.2290	0.2338	0.1814	0.2711	0.2209	0.4363	0.4420
France	0.4360	0.4425	0.5147	0.4498	0.4201	0.4617	0.4193
Germany	0.3080	0.3456	0.3169	0.3340	0.3641	0.3848	0.4044
Greece	0.2990	0.3020	0.2784	0.2826	0.3035	0.3242	0.3011
Ireland	0.2470	0.2245	0.2234	0.2348	0.2355	0.2367	0.2492
Italy	0.5560	0.3875	0.3829	0.3890	0.3466	0.3719	0.3265
Japan	1.0000	0.9750	0.8941	0.8896	0.9029	0.8903	0.8618
Luxembourg	0.5860	0.3674	0.3909	0.3784	0.3512	0.3357	0.3334
Netherlands	1.0000	1.0350	0.9025	0.9765	1.5751	0.9498	0.9422
Norway	0.7000	0.6986	0.6350	0.5988	0.5162	0.5905	0.6342
Portugal	0.2590	0.2585	0.2673	0.2852	0.2655	0.2538	0.2584
Spain	1.0000	0.9330	0.7940	0.8107	0.7969	0.7809	0.7505
Sweden	0.5650	0.5531	0.6051	0.6983	0.7025	0.6505	0.6375
Switzerland	0.3850	0.3746	0.4795	0.5054	0.6626	0.6261	0.6474
USA	1.0000	0.9860	0.9061	0.8853	0.8694	0.8754	0.8965
Great Britain	0.4030	0.4074	0.3899	0.3915	0.4130	0.3944	0.3763
mean	0.5282	0.5087	0.5205	0.5485	0.5579	0.5708	0.5717

Technical Efficiency

Case3

	93	94	95	96	97
Australia	0.4970	0.5894	0.6961	0.6676	0.5948
Austria	1.0000	1.0000	0.3730	0.2395	0.4306
Belgium	0.6640	0.6673	0.7494	0.7569	0.7645
Denmark	0.5070	0.4817	0.5910	0.6389	0.6523
Finland	0.5370	0.4065	0.3939	0.4534	0.4956
France	0.6820	0.6131	0.6058	0.6942	0.7518
Germany	0.6000	0.8220	0.8097	0.8534	0.9575
Greece	0.8810	0.8325	0.8917	1.0004	1.0004
Ireland	0.5730	0.5065	0.3227	0.6392	0.5957
Italy	1.0000	1.0000	1.0000	1.0000	1.0000
Japan	1.0000	1.0000	1.0000	1.0000	1.0000
Luxembourg	1.0000	1.0000	1.0000	1.0000	1.0000
Netherlands	0.7740	0.7601	0.9995	0.9995	0.9995
Norway	0.9760	0.8716	0.7356	0.7054	0.6631
Portugal	0.4380	0.4621	0.4371	0.4258	0.4045
Spain	0.7980	0.8164	0.7608	0.8019	0.6584
Sweden	0.7720	0.7643	0.9943	0.9327	0.9756
Switzerland	0.4040	0.5357	0.5561	0.6634	0.7980
USA	1.0000	1.0000	1.0000	1.0000	1.0000
Great Britain	0.5600	0.5370	0.5832	0.7162	0.6704
mean	0.7332	0.7333	0.7250	0.7594	0.7706

Total Factor Productivity

Case3

	93	94	95	96	97
Australia	0.4840	0.5910	0.6223	0.6030	0.5777
Austria	1.0000	1.0480	0.3113	0.1640	0.3028
Belgium	0.6420	0.6555	0.6253	0.5590	0.5445
Denmark	0.4660	0.4511	0.4791	0.4599	0.4539
Finland	0.4730	0.3808	0.3191	0.3736	0.4189
France	0.3470	0.3512	0.3280	0.3191	0.4050
Germany	0.3570	0.4377	0.4696	0.4527	0.4812
Greece	0.5510	0.5758	0.6593	0.7628	1.5180
Ireland	0.4810	0.4291	0.4200	0.4305	0.4077
Italy	1.0000	1.1200	1.2286	1.1230	1.0163
Japan	0.9590	1.0731	1.0227	1.0401	0.9662
Luxembourg	0.3640	0.4361	0.4522	0.3979	0.4147
Netherlands	0.7630	0.7790	1.2963	0.8154	0.8211
Norway	0.8780	0.8561	0.6874	0.6448	0.7099
Portugal	0.3570	0.4106	0.3637	0.3550	0.3536
Spain	0.7180	0.8271	0.8429	0.8150	0.7971
Sweden	0.7550	0.7603	0.8416	0.6969	0.7038
Switzerland	0.3920	0.5363	0.5545	0.4724	0.5830
USA	0.6350	0.5842	0.6181	0.6576	0.6590
Great Britain	0.3560	0.3386	0.3413	0.3757	0.3378
mean	0.5989	0.6321	0.6242	0.5759	0.6236