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Productivity of Service Providers: Microeconometric measurement in the case of hair salons

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Productivity of Service Providers: Microeconometric Measurement in the Case of Hair Salons

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Abstract

In this paper we measure the productivity of service industries using micro dataset. The "service industry" is a very broad category including many sectors, such as education, finance, insurance, transportation, logistics, food service, and many more. These sectors exhibit, in our understanding, very different structures from one another, and it is not easy to construct one model that can be applied to all service sectors. It is common in the literature to measure the productivity of manufacturing industries, typically by the Solow residual or its modification from production function estimations. We may possibly follow the same track in studying productivity in service industries. However, they may be different in their structures. In the case of hair salon services, it is impossible for service providers to hold inventories. They can serve only when customers arrive at the hair salon. In this paper, we study the case of hairdressers using micro data collected by hair salons. We believe that our approach is applicable to the food industry, beauty industry and health clinic industry.

Key words: Productivity; Capacity; Individual Service Industry; Hair Salon

JEL classification: D21, D22, D24, L84

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1. Introduction

Since the burst of bubble economy in early 1990's, the growth rate of Japanese economy has not been increasing obviously, and it is said the productivity keeps declining. This period is sometimes called the lost decade. A number of researchers investigate what did occur in the period. The government also tries to answer the question seeking for an effective policy to raise the growth rate of GDP.

It is common in the literature to measure productivities of manufacturing industries, typically by Solow residuals or its modification from production function estimations. In estimation of production function of firms, there are problems of endogeneity and self selection due to firm specific productivity shocks and entry/exit decisions. There are some methods proposed to handle the problems such as Olley and Pakes (1996) and Levinsohn and Petrin (1999, 2003). Since these epoch making works, along with recent progress of accessibility to micro data, we have yield more precise statistical empirical results in various levels of aggregation.

We may possibly follow the same track in studying productivities of service industries. However, as mentioned in Bosworth and Triplett (2004), it is harder to obtain capital stock data than manufacturing industry. We should mention there exists a serious data availability problem in service industry.

"Why growth rate keep declining?", one possible reason for the low or negative growth rate is low productivities of industries. Especially, it is said that it is due to low productivity of service industry according to OECD report and some others. Bosworth and Triplett (2004) survey the measurement of U. S productivity for very broad class of service industries by government statistics and showed retail and some personal service industry achieved lower productivity in 1990's. These findings are basically in terms of macro-economic situation and using labor productivity.

We do not believe all the Japanese service industries decline in productivity. In order to determine what causes such a phenomenon, we need to investigate in detail which section in service industry exhibits a low productivity. Foster, Haltiwanger and Krizan (2006) investigate the reason of fluctuating retail productivity in U. S. They showed a positive correlation between growth rate and entry of higher labor productivity's establishments. A problem of data availability, previous works have used "Labor Productivity" instead of TFP (Total Factor Productivity) as a measure of productivity in service industry. It could be easy to imagine that if capital stock affects their production procedures, it provides biased productivity. Beyond this data availability problem, Morikawa (2008) and Morikawa (2010, *forthcoming*) adopted the number of physical equipments / facilities as capital stock variables instead of monetary based tangible capital stock. They could examine TFP for personal service industry by establishment level data. In order to get rid of demand effects thorough price from the productivity, they use quantity data for both output and input variables instead of monetary based data. Moreover, Morikawa (2008) consider the demand fluctuation of TFP explicitly by using weekend and seasonability effects in their empirical model.

In this paper, we would like to measure the productivity of service industries from micro dataset in terms of individual worker level. "Service industry" is a very broad class including a lot of sectors, such as education, finance, insurance, transportation, logistics, food service, and many more. They exhibit, in our understanding, different structures from one to another, and it does not seem easy to construct one model which accounts for all the service sectors. Mas and Moretti (2009) specify the model for the cashiers' productivity in supermarket and examine the progress of productivity through the peer effects among cashiers individually.

In terms of hair salon services, it is impossible for service providers to hold inventories. They can serve only when customers arrive at hair salons. If we examined the labor productivity or TFP for the hair salon or others which have similar structure, the calculated productivity should include demand effects. It means that we can not identify the pure technological productivity from these labor productivity or TFP. The labor productivity and TFP prevent us from the right policy making. In this paper, we study the case of hairdressers productivity using micro data collected by hair salons. We construct the demand and supply sides model and define the new measure of productivity. Our object is identification of productivity.

In our empirical results, we could observe that each hairdresser's productivity or skill increases in most cases after a hairdresser enters the hair salon year by year. We also estimate a set nonparametrically which includes capacity of each hairdresser. The set looks to move upward with the accumulation of experiences. This indicates the possibility that the skill of hairdressers increases with experience and their capacity increases. Recently, it is said that the productivity of service industry has kept lower level and also one of the reason of economic recession in Japan. Surprisingly, in our results, micro level productivity is not decreasing obviously. According to our results, we would like to suggest that these microdata analysis help to measure the productivity in service sector and understand their both of supply and demand sides structure. In the case of macro or industrial approaches, we should consider to get rid of the demand effects on TFP using these structural approaches. We believe that our approach is applicable to food industry, beauty industry and health clinic industry, which seem to possess similar production structures.

The following section defines the productivity of a hairdresser and explains a theory of consumer behavior, hair salon owner behavior and hairdresser behavior. Section 3 describes the dataset and Section 4 provides empirical results. Section 5 concludes.

2. Behaviors of consumers, hair salon owners and hairdressers

2.1. **Skill of hairdressers and their behaviors.** We would like to define the productivity of a hair salon. We focus only on hair cutting for simplicity among all services supplied in hair salons. It will be possible to extend this idea to other services such as permanent wave and coloring. The source of value added in hair cutting must be the subjective value (or willingness to pay) for a customer before hair cutting and after hair cutting. Obviously, the value is higher if the state of the latter is better. It must depend on hair cutting skill of a hairdresser in measuring his/her productivity. Obviously, management of hair salon and other points must be important, but we concentrate on the skill of a hairdresser in this paper.

We would like to provide a definition of "productivity" or skill of a hairdresser. Let t be time for the hairdresser to spend on a hair cut. If he/she takes more time and carefully cuts hair, the performance will be better and vice versa. Then we may assume quality of a hair cut, Q, is an increasing function of t. Namely, $Q = Q(t)$ and $dQ/dt \geq 0$. It is natural to define that "high skill hairdressers" are those who can attain certain level of quality in a shorter hair cut time, or those who can attain better quality given a certain hair cut time. This motivates us to define the productivity A implicitly as follows. In view of the above discussion, we think a hairdresser with productivity (or skill) A can cut hair with quality $Q = Q(A, t)$, where $\partial Q/\partial A > 0$, $\partial Q/\partial t > 0$. One possible specification may be $Q(A, t) = At^{\alpha}$ as in the case of Cob-Douglas production technology where $\alpha > 0$ is a parameter. Here we may regard $Q(A, t)$ is the production function with input time t. However, neither output Q nor input t are observed unlike the case of manufacturing industry. Obviously, hairdressers with larger A are more skillful. Figure 1 illustrates the technology of hairdressers with different skills. Hairdresser A has a better skill than B because the former can attain better quality in a given time than the latter.

It is natural to think that hairdressers are supposed to provide a hair cut service of quality greater than, say $\underline{Q}$ within time less than $\bar{t}$. See Figure 1. We may consider that these are externally determined by their competitors around the hair salon. Alternatively, we may also think that different hair salons can choose different combination of ($\underline{Q}$,$\bar{t}$), which may be considered as their strategy in a customer attracting game. In any case, the owner of the hair salon require the hairdressers to keep it. Then, the production possibility set is

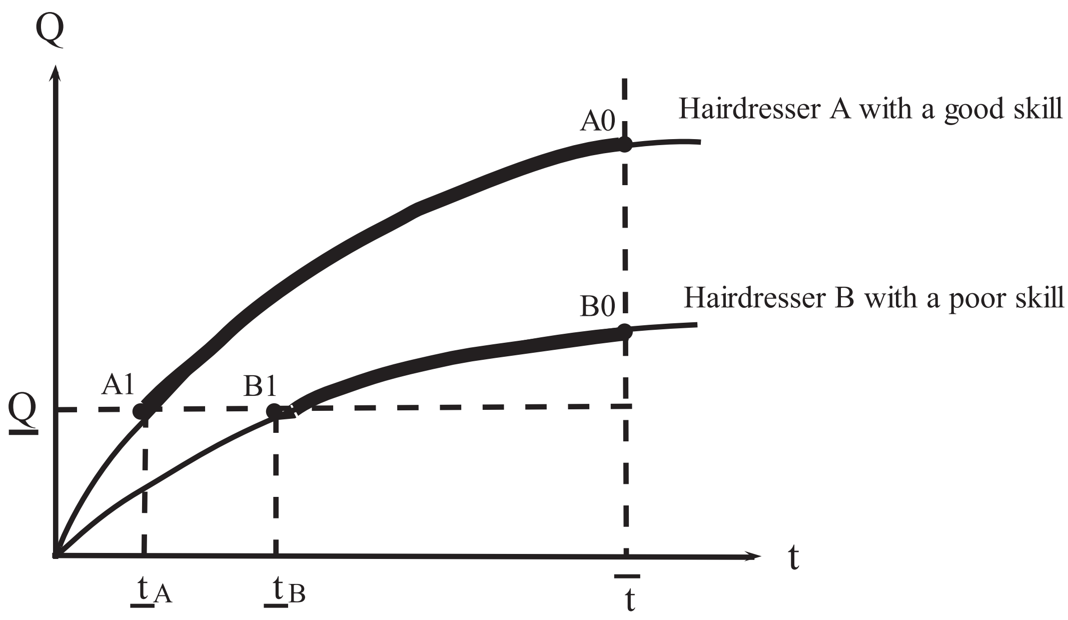

FIGURE 1. Different Skills of Hairdressers

restricted to $A_0A_1$for hairdresser A and B_0B_1 for hairdresser B. This causes a capacity of number of hair cuts per day. Highly skilled hairdresser A can attain level $\underline{Q}$ within time $\underline{t}_A$, while low skilled hairdresser B needs time $\underline{t}_B$. Because working time T in one day is the same for all hairdressers, hairdresser A can handle $T/\underline{t}_A$ customers per day keeping the minimum quality level, which is obviously greater than hairdresser B. This number is obviously closely related to the skill A of hairdressers, and thus it is an interesting point to estimate the capacity. To be more precise, easy calculation yields that

$$\underline{t}_A = (\frac{\underline{Q}}{A_A})^{1/\alpha_A}$$

where $A_A$and α_A are A and α of hairdresser A, and the capacity for hairdresser A is

$$C_A = T/\underline{t}_A = T(\frac{A_A}{\underline{Q}})^{1/\alpha_A}.$$

Hairdressers typically have the following possible carrier paths. Firstly, they would like to run their own hair salon and work as a manager rather than hairdressers. Some hairdressers work as a top hairdresser after becoming a hair salon owner. Secondly, they work on as a hired hairdresser without owning their own hair salons. Finally, the others quit this industry. Thus we may regard that they typically face a dynamic programing problem. It is not our purpose here to formulate such a problem, solve and use it for empirical examination as in structural econometric approach. We only assume that they try to increase A as it is incentive compatible for them in view of their carrier/salary system. Their salary increases depending on their own sales amount, which is directly affected how many royal customers they have. Of course, if their skill is higher, they can attract more customers. Therefore, hairdressers try to increase their skill A. This is normally done through on the job training and/or training after closing.

2.2. **Consumer's selection model.** Suppose consumer k obtains utility $U_{ki} = U(Q_i, t_i, p_i) + \epsilon_{ki}$ when she has a hair cut at hair salon i. p_i is the price of hair cutting. k will have the next hair cut again at the same hair salon if

$$U(Q_i, t_i, p_i) + \epsilon_{ki} \geq \bar{U}$$

where $\bar{U}$ is the reservation utility from going to some other hair salon. Supposing $\epsilon \sim N(0, \sigma^2)$ and Φ is the cdf of standard normal random variable,

$$P(k\ choose\ i\ for\ next\ hair\ cut) = \Phi(\frac{U(Q_i, t_i, p_i) - \bar{U}}{\sigma}).$$

Hence we can assume that hair salon i faces the demand $D = d(Q_i, t_i, p) + u_i$.

2.3. **Hair salon owner's (manager's) behavior.** Here we drop subscript i. Given w, the wage of a hairdresser, a hair salon owner selects the number of hairdresser x and p as follows:

$$\max_{x,p}\ \Pi = E\{p \min[\frac{x}{t}, D]\} - wx$$

subject to the demand D. Let F and f be the cdf and pdf of u. Because

$$E\{\min[\frac{x}{t}, D]\} = d + (\frac{x}{t} - d)\{1 - F(\frac{x}{t} - d)\} + \int_{\frac{x}{t}-d} uf(u)du,$$

where $d = d(Q(A,t), t, p)$, the first order conditions are

$$\frac{\partial \Pi}{\partial x} = \frac{p}{t}[(1 - F) - 2(\frac{x}{t} - d)f(\frac{x}{t} - d)] - w = 0$$

$$\begin{aligned}\frac{\partial \Pi}{\partial p} &= d + (\frac{x}{t} - d)\{1 - F(\frac{x}{t} - d)\} + \int_{\frac{x}{t}-d} uf(u)du \\ &+ p\{d_p - d_p(1 - F(\frac{x}{t} - d)) + 2(\frac{x}{t} - d)f(\frac{x}{t} - d)d_p\} = 0,\end{aligned}$$

where $d_p = \partial d(Q, t, p)/\partial p$.

2.4. **Equilibrium.** Given the production possibility set $Q \leq Q(A, t)$, a customer is willing to have a hair cut by the hairdresser who gives him/her the highest utility. It must be reasonable to assume that $U(Q, t)$ is an increasing function with respect to Q and a decreasing function of t. Customers have a choice set of hairdresser with different skills. We illustrate the situation in Figure 2. Consumer 1 cares very much about the quality while consumer 2 does not care it too much, but rather would like to save time. Hairdresser C performs good if he/she takes time, and hairdresser D is good in cutting quickly. In such a case, customer 1 choose E_1 and customer 2 choose E_2. We may regard that each of hairdressers C and D owns a hair salon. Then hair salon C attracts consumers who have indifference curve like consumer 2, and hair salon D attracts the those like consumer 2. This is a kind of equilibrium in product differentiation. We do not discuss much about the price which should be a very important factor in a larger scale analysis with dataset including many different hair salons. The reason is that we only have a very detailed dataset for only one hair salon, and we cannot examine the effect of price by this data.

3. Data description

We obtained the data of customers' attributes and record of their customers from a hair salon. The hair salon is located in Japan's third largest city, Osaka. The salon is easily accessible from certain railways stations, business offices, restaurants, and shopping malls. Nearly all Japanese hair salons require the customer to fill in a questionnaire on their first visit. Salon owners can obtain the data on the customer's sex, age, occupation, address, hobby and some other preference. The hair salon opened since July 2003, and we observed

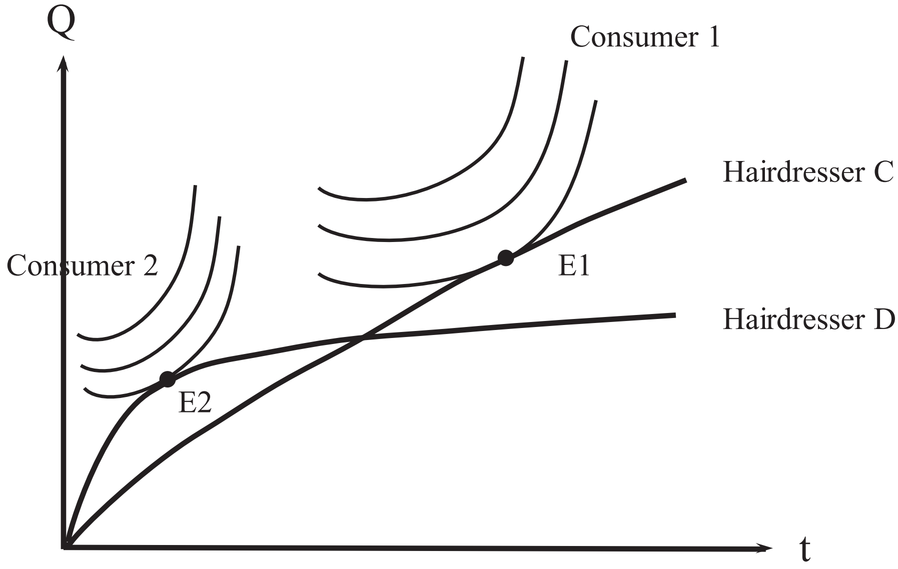

Figure 2. Customer's Choice Sets

them from July 2003 to March 2010 (2418days). The hair salon provides the customers with various hair products and services including not only haircut, color, and permanent wave, but also nail and facial care, makeup, and so on. As you know, their main services are haircut, color, and permanent wave and their share of total number of treatments are 36%, 21% and 10%, respectively. The three services yield more than 80%'s sales of the total sales.

In this paper, we use the customers' sex, age and the distance between the salon and their address as demographic variables to estimate the productivity in section 4.1. They have 16000 customers and it comprises approximately more than 90% females. The average age of customers is 29 years old (youngest is 12 and oldest 84). Thus, the majority of customers lie between 20 and 30 years of age. The distance between the residences of the customers and the salon vary greatly, we observed forty prefectures in their address. The mean of distance is around 10 km. Surprisingly, the maximum distance is more than 1000 km, however, the customers who live in the place such far from the hair salon are only 2%. This might be due to the fact that the customers happened to visit the salon while they had some other tasks planned in the neighborhood, or because they wrote down another address, e.g., parent's address since they dislike receiving many direct mails. In any case, it is difficult to regard these customers as frequent customers and and hence they are treated as outliers. The rest of 98% customers are from four prefectures (Osaka, Kyoto, Hyougo and Nara) and 88% of customers are from Osaka prefecture. We abstract the customers who live within 50km from the hair salon and about 3% customers are removed. We can use these demographic information from the initial questionnaire and also customers' daily based record of the visits. The daily based record holds the payment and hair hairdressers' name for each customer's each treatment, it makes possible to be aggregate the experiences of hairdressers for the seven years and examine their productivity.

4. Empirics

This section provides a model of estimating the productivity of a hairdresser at a certain period of time (year). We take into account two aspects which has not been considered in the literature of manufacturing industry. Firstly there is a maximum possible number of customers a hairdresser can give hair cuts per one day. This is because it takes certain time to cut hair of one customer keeping certain (minimum required) quality, and this determines how many customers he/she can handle in one day. Secondly, the number of customers in a day is determined by the demand of the day unless it exceeds the maximum number per day. In our theory developed above, both of them depend on the skill A of the hairdresser. We provide the estimation model of the number of customer in one day for a hairdresser. In Section 4.1 we provide an econometric model specifying the utility function of customers and skill function of hairdressers, which provides a point estimates of A for each hairdresser every year. Section 4.2 considers to estimate the capacity. We do not obtain point estimates, but we propose to estimate a set which includes the capacity.

4.1. **Econometric model for productivity estimation.** We use the following specification for the estimation purpose. The utility function of customers is

$$U(Q) = \log(Q).$$

The quality function of hairdresser i is

$$Q_{i,y}(t) = A_{i,y}t^{\alpha}.$$

Here we assume that productivity A changes every year and subscript y indicates year. Letting T be the business hour of the hair salon (9 hours, e.g.) and n_{id} be the number of customers hairdresser i give a hair cut on day d. Then

$$t_{id} = \frac{T}{n_{id}}$$

is the time spent to give a hair cut for each customer. Then, customers who visited on day d for a hair cut receive the utility

$$U(Q_{i,y}(t_{id})) = \log Q_{i,y}(t_{id}) = \log(A_{i,y}T^{\alpha}) - \alpha \log n_{id}.$$

Suppose the duration between two hair cuts denoted as M is independent of ϵ. Then the probability of revisit in certain period of time (90 days, e.g.) is, from the above discussion in Section 2.2,

$$P(\textit{revisit in } 90 \textit{ days}) = P(M < 90)P(\epsilon > \bar{U} - U(Q)) = \gamma P(\epsilon > \bar{U} - U(Q))$$

where $\bar{U} > 0$ is a reservation utility obtained from other hair salon. This motivate us to estimate the following probit model,

$$P(\textit{revisit in } 90 \textit{ days}) = \Phi(\log(A_{i,y}T^{\alpha}) - \bar{U} - \alpha \log n_{id}).$$

We estimate this model for each hairdresser using data year by year. This yield estimates of $\delta_{i,y} \equiv \log(A_{i,y}T^{\alpha}) - \bar{U}$ every year for hairdresser i. Our primary object is to measure A_i, the productivity or skill. We immediately know that we cannot identify all of $A_{i,y}, \bar{U}$ separately. But we can identify $\delta_{i,y+1} - \delta_{i,y} = \log(A_{i,y+1}/A_{i,y})$ which is regarded as an index of productivity growth, which may be sufficient so far.

A hairdresser can cut hair with quality $\bar{Q}$ when the number of customer in a day is less than or equal to T/t^*. When there are more demands than T/t^*, hairdresser cannot operate at the equilibrium E_1. He/she needs to shorten hair cutting time per person yielding a lower quality. Namely, he/she operates at some points on the production function left from E_1. Using this, we estimate the production function $Q(A, t)$. We need to be careful that hairdressers i would not spend $t_{id} = T/n_{id}$ for a hair cut when the demand of a day (n_{id}) is very low, when he/she will spend only t^* for a hair cut. thus we replace n_{id} by T/t^* when $n_{id} < T/t^*$. This number is different from hairdresser to hairdresser.

There is one obstacle in our estimation for young (new) hairdresser. They do not give a lot of hair cut in the very beginning because of some managerial reasons. He/she does not yet have sufficiently good skill, so that the manager will carefully assign customers. Otherwise, they may lose their customers. But the number of hair cuts per day will gradually increases. This period is regarded as a training time and their skills may progress rapidly. As a result, the return probability and number of hair cuts have positive correlation. This is like a rapidly growing manufacturing company shows a positive correlation between its capital and labor when the time series observations are used, even though they are basically substitutes. It is certainly an interesting topic to investigate the skill acquiring path of new hairdressers.

Our method is simple but it has some interesting features avoiding cumbersome technicality. Firstly, there is no endogeneity problem because the explanatory variable is predetermined. Secondly, There is no censoring in dependent variable, while the explanatory variable is censored. Censoring in explanatory variables does not cause bias.

4.2. **Nonparametric Identification and estimation of Capacity.** Previous section provides a method to estimate A based on a fully parametric econometric model. In this section, we propose to estimate the capacity which is very closely related number to skill A in completely nonparametric manner. As discussed above, each hairdresser has his/her own capacity on how many hair cuts they can give in one day. Number of hair cuts in a day is determined as a minimum of the capacity and the demand of the day. The capacity could be regarded as a fixed number for each hairdresser as explained in Section 2.1. In view of the data, however, it may be more suitable to assume that the capacity may change day by day, say, depending on the hairdressers' conditions or other external reasons. Also, they may sometimes need to operate below the predetermined level $\underline{Q}$ in order to meet the "too many" demands, though they basically do not do it. Thus we rather assume it is not completely fixed.

In this hair salon, they sometimes reject demands from customers on busy days such as Fridays, Saturdays, Sundays, national holidays, and other special days as around Christmas and new year days. But it never happens on non-busy days such as ordinary Tuesdays, Wednesdays and Thursdays. This may help us identify the capacity as a set. We can think the capacity is greater than the maximum of customer number on non-busy days. Also, the "standard"(or average) capacity must be smaller than the maximum number in a whole year. We also have an information that hairdressers are supposed to be able to give 8 hair cuts in a day. Therefore, we can estimate the capacity by the set;

$$(\max_{d \in non-B_y} n_{id}, \max_{d \in B_y} n_{id}).$$

Here B_y is the set of busy days in year y and $non-B_y$ is that of non-busy days. We need to be careful in interpreting the upper bound as it depends on the model of random capacity at lease in part, but we believe the lower bound is very reliable.This indicates the possibility that the skill of hairdressers increases with experience and their capacity increases. As explained above, we believe the lower bound is reliable.

4.3. **Empirical results.** We point-estimate the productivity or skill A of each hairdresser year by year using the parametric framework explained in Section 4.1. We pool the data for six months to estimate the production function in this period of time, changing the starting date every thirty days. In figure 3, we observed that the productivity increases in most cases after a hairdresser enters the hair salon except the very beginning of his/her carrier in this hair salon. In terms of estimation of α, we basically expect the sign to be negative if there is no productivity change. In the case of Hairdressers 1 and 5, we observe such expected sign in figure 4. As discussed above, the sign could be positive especially in the beginning of their carrier because of lasting productivity growth. Some hairdressers seems to have zero coefficient. We may interpret it in two ways. One is that there are not enough variation in the direction of n. The other possibility is that the specification of $Q = At^{\alpha}$may not be reasonably good. We assumed that hairdressers can increase the quality of hair cuts by taking more time, but there could be difference in skill from one hairdresser to another. From these results, we think some hairdressers have rather flat quality-time curve. In such a case, the estimates of α tend to be close to zero. We can point out that even for those who have non-negative α, it seems the value is decreasing with experience.

We also estimate a set nonparametrically which includes capacity of each hairdresser. We showed the results in figure 5. The set looks to move upward with the accumulation of experiences. This indicates the possibility that the skill of hairdressers increases with experience and their capacity increases. In order to show the robustness of these results, we checked the total number of hair cut treatments and number of customers for each year in figure 6. In these periods, the salons scale / number of customers has tended to decline, it makes us possible to support our claim that hairdressers capacity have increased through their experiences even the demand of salon get shrink. As explained above, we believe the lower bound is reliable. In our estimation, the lower bound tends to go up as time passes.

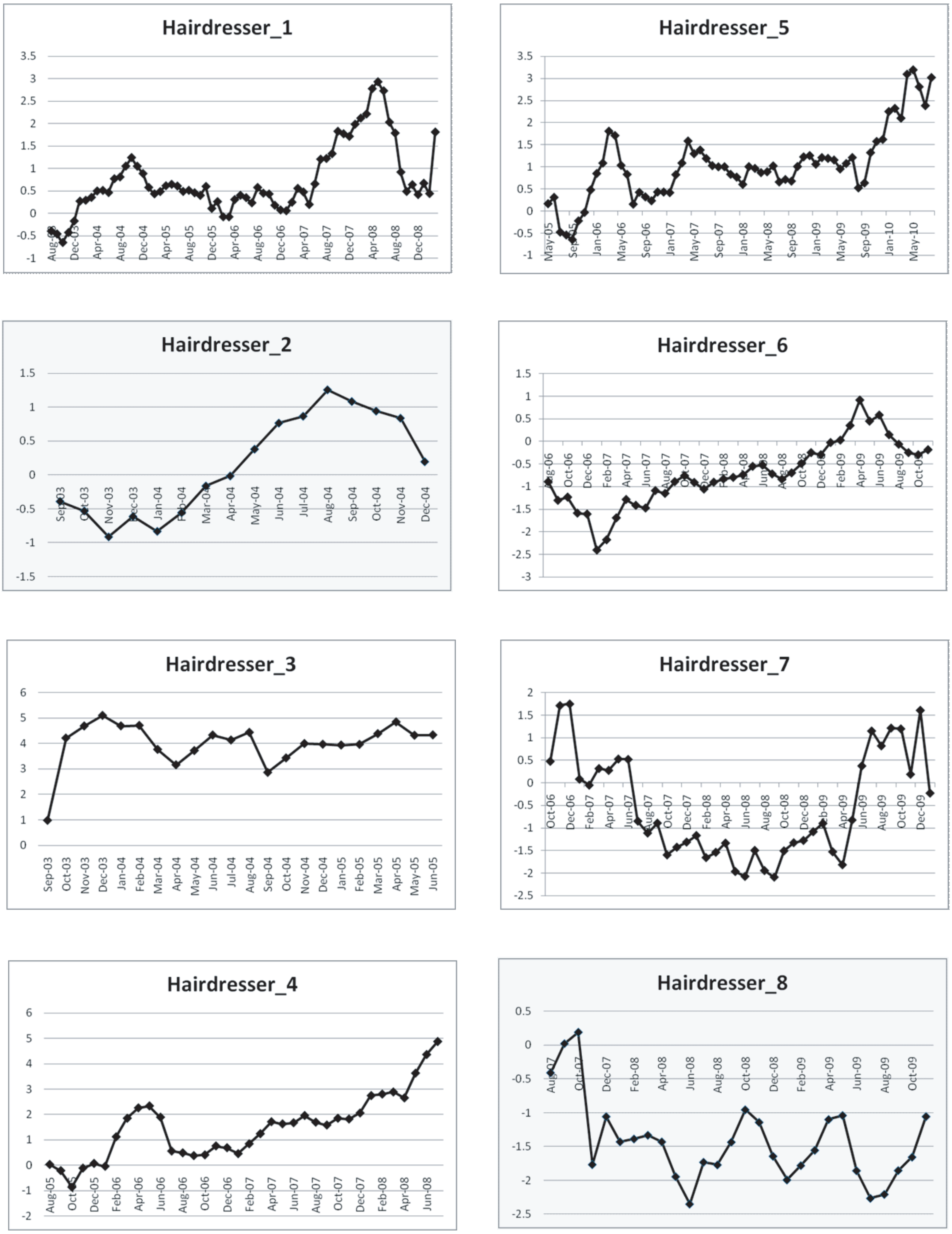

FIGURE 3. Measuring the Hairdresser's Productivity

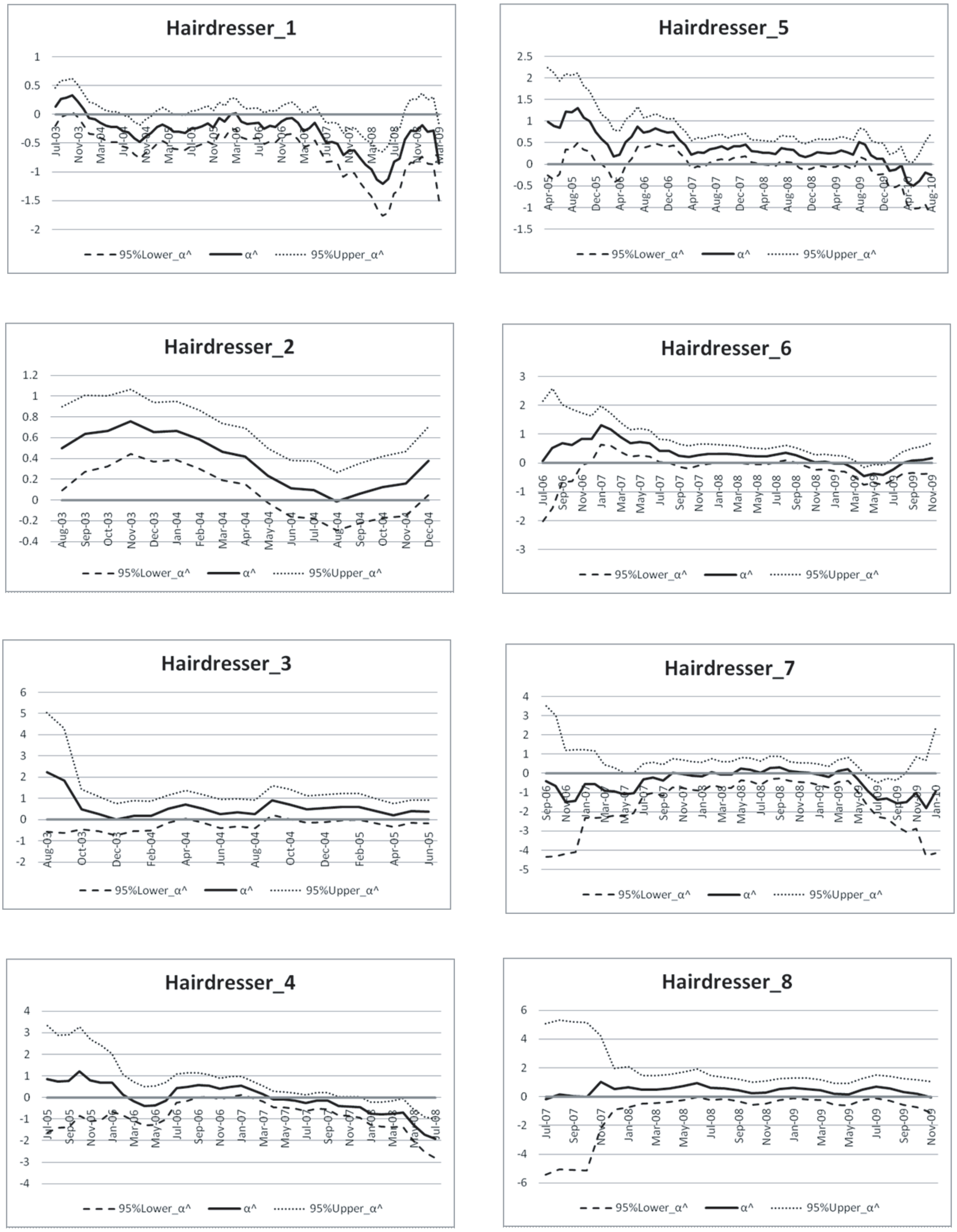

FIGURE 4. Estimation of α

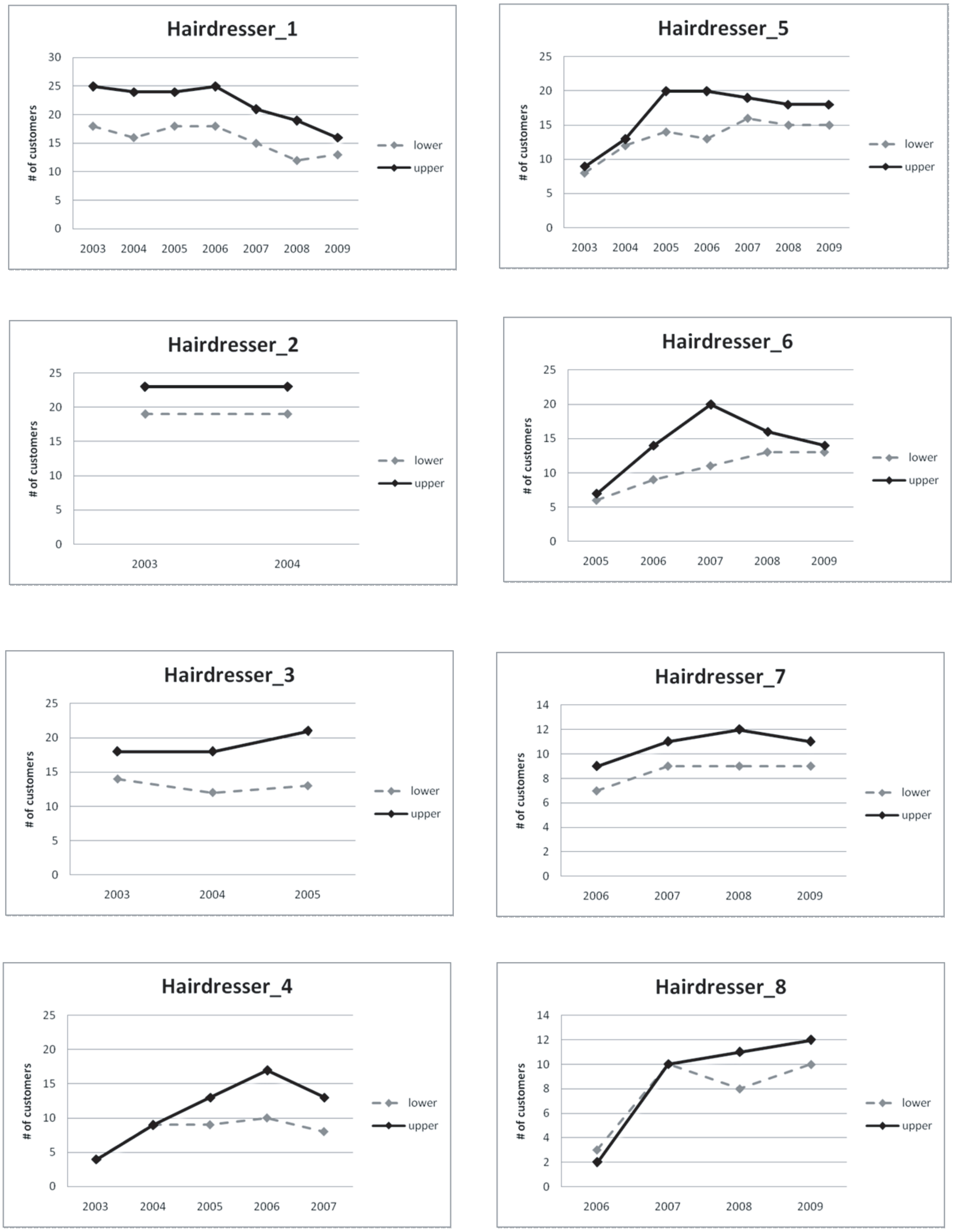

Figure 5. Bound Estimation of Capacity

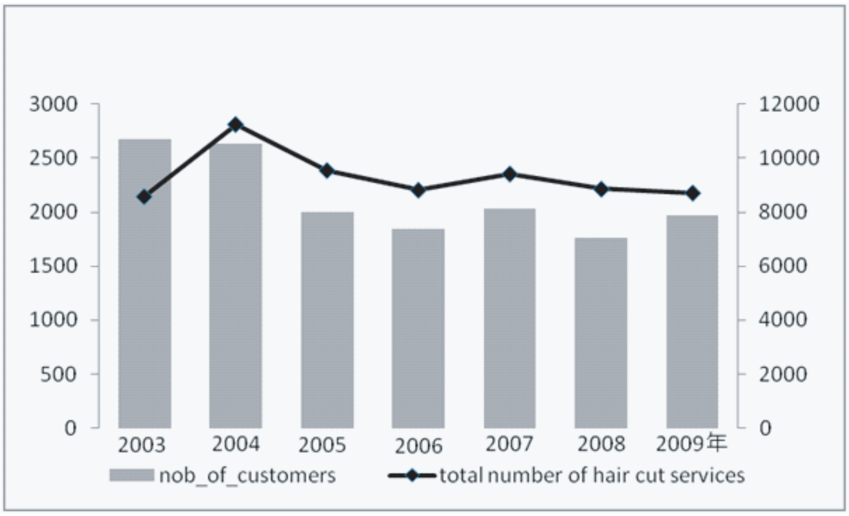

FIGURE 6. Scale of the Hair Salon

5. CONCLUSIONS

We have tried to measure the productivity of service industries, especially hair salon using micro-data. We propose a definition of (productivity or skill) of hair salon in terms of the quality. The quality itself is unobservable unless we ask customers by questionnaire. Our approach is that if customers are satisfyed with the hair cutting quality, they will return for the next time, and thus probability of re-visiting can be regarded as a proxy to the quality. Using this, we measure the productivity of a hairdresser. It is impossible to measure the absolute level of skills, but we can measure the relative difference from some basis.

In the empirics, we point-estimate the productivity or skill of each hairdresser year by year and observed that the productivity increases in most cases after a hairdresser enters the hair salon except the very beginning of his/her carrier in this hair salon. In the estimation of α, we observe some hairdressers show negative sign, but some others have non-negative value. We interpret that the skill and its functional form can be different for different hairdressers. We also estimate a set nonparametrically which includes capacity of each hairdresser. The set looks to move upward with the accumulation of experiences.

This indicates the possibility that the skill of hairdressers increases with experience and their capacity increases.

Our micro econometric analysis was reflected the structure of supply and demand sides and it can be possible to identify "productivity" of the hair salon. We conclude that our micro econometric analysis should be useful ways for defining and measuring the productivity of the service sector. We believe that our approach is applicable to food industry, beauty industry and health clinic industry, which seem to possess similar production structures.

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