Journal of the Operations Research Society of Japan
Vol. 30, No. 2, June 1987

A DEMAND FORECASTING METHOD FOR NEW TELECOMMUNICATION SERVICES

Hiroshi Saito
NTT Electrical Communications Laboratories

(Received August 9, 1986; Revised January 16, 1987)

Abstract In this paper, a demand forecasting method for new telecommunication services using historical data of existing telecommunication services is proposed. This method has two phases. First, a regression model is chosen using the results of forecasts for existing services. Then, the new service demand forecasts by that model are corrected using the correction coefficient. The correction coefficient is determined by errors in the forecasts for existing services. Numerical results using field data are also shown.

1. Introduction

On developing the Integrated Services Digital Network, many kinds of new telecommunication services are planned. When the communication systems of these services are designed, it will be essential to forecast the demand of each service accurately for dimensioning of resources.

In Japan, a regression model including economic factors as explanatory variables has been used to forecast the demand for telephones. In addition, another regression model reflecting economic situations and the number of subscribers has been used for the telephone traffic forecasting [11]. These models are based on the historical data of demand which is obtained over a long period. However, there is little historical data for the new service. Therefore, it is difficult to directly adopt these models and apply them to forecast demand for new telecommunication services and therefore some good ideas are necessary in order to adopt them.

A few methods have been proposed to forecast the demand of new telecommunication services. Jennings-Williams-Gilstein [6] proposed the method for forecasting the replacement scenarios from existing services to new services. However, this method did not include the calculation method for concretely projecting the demand of new services. Similar problems mentioned above occur with the forecasting involved for new products. Kimura and Tsuruta[8] showed the possibility of adopting the logistic curve for VTR demand forecasting. However, they also expressed the difficulty in estimating parameters. Mikami[10] forecasted the demand of the new 'door' by Quantification Method I[5] using height and color as explanatory variables. In this case, based on the historical states record of many doors to date, the relationship between the users' preference and each factor (height or color) was cleared enough to forecast the demand of 'new doors' accurately. However, it cannot be expected that such relationships become clear with telecommunication services. Katsumura[7] tried to forecast the rate of replacement from an old product to a new product based on the experience of the new product's engineers and marketing division staff using a regression analysis. It is expected that most of the new telecommunication services will not replace the old ones but add to them. Therefore, Katsumura's method cannot be directly adopted. However, it is important to take advantage of such prior information on new products or new telecommunication services in order to forecast their demand.

In this paper, a demand forecasting method for new telecommunication services using historical data of existing telecommunication services is proposed. This method has two phases. First, a regression model is chosen using the results of forecasts for existing services. Then, the new service demand forecasted using that model is corrected by the data from existing services. This method of forecasting demand proposed in this paper implicitly assumes that the tariff of the new services will not change and the sales effort for new services and existing services are the same.

2. A Demand Forecasting Method

While introducing a new service, it may be possible to forecast demand by using the new service's data. For example, when there is more data than the number of regression parameters, it is possible to forecast in principle using this regression model. However, forecasting is very difficult when the amount of data is insufficient. In this paper, a forecasting method using the historical data from existing services is proposed to make up for the shortage of historical data for a new services.

2.1 Choice of models

In an effort to fit a regression model to a certain series of data, a forecaster usually chooses a regression model using criteria such as AIC[1] or multiple correlation coefficient[4], calculated from the data. However, in the case of a new service, the interval in which the service's historical data is obtained is short compared to the length of the lead time. In the proposed method, a regression model is chosen from the results of demand forecasts for existing services.

Regression models under consideration are as follows. Explanatory variables consist of economic factors and time because of the ease in obtaining data. The number of regression parameters should not be more than three, because there is not a great deal of historical data and demand forecasting using complicated models has not been always successful[2], [9], [12]. In addition, the form of the regression model is linear or log-linear for the easy calculation. Candidate models are shown in Table 2.1.

Table 2.1 Candidate Models

1	$y = a + bt + ct^2$	16	$y = a \cdot \exp(bt + c\gamma x)$
2	$y = a + bt$	17	$y = a \cdot \exp(b\gamma x)$
3	$y = a + bt + cx$	18	$\gamma y = a + bt + c\gamma x$
4	$y = a + bx$	19	$\gamma y = a + b\gamma x$
5	$y = a \cdot \exp(bt + cx)$	20	$y = a \cdot \exp(bt + c\gamma x)$
6	$y = a \cdot \exp(bx)$	21	$y = a \cdot \exp(b\gamma x)$
7	$y = a \cdot \exp(bt)$	22	$\Delta y = a + bt + ct^2$
8	$\gamma y = a + bt + ct$	23	$\Delta y = a + bt + cx$
9	$\gamma y = a + bt$	24	$\Delta y = a + bx$
10	$\gamma y = a + bt + cx$	25	$\Delta y = a \cdot \exp(bt + cx)$
11	$\gamma y = a + bx$	26	$\Delta y = a \cdot \exp(bx)$
12	$\gamma y = a \cdot \exp(bt + cx)$	27	$\Delta y = a + bt + c\gamma x$
13	$\gamma y = a \cdot \exp(bx)$	28	$\Delta y = a \cdot \exp(bt + c\gamma x)$
14	$y = a + bt + c\gamma x$	29	$\Delta y = a \cdot \exp(b\gamma x)$
15	$y = a + b\gamma x$		

where

y : demand

t : time

x : economic factor (Gross National Expenditure)

$\Delta y(t) = y(t) - y(t - 1)$

$\gamma y(t) = y(t) / y(t - 1)$

$\gamma x(t) = x(t) / x(t - 1)$

a, b, c : regression parameters

These candidate models are employed to forecast the demand of existing telecommunication services using only their historical data during the starting period of their services. Then, those forecasted results are compared to the observed data.

The details are as follows. The i-th existing service is assumed to start at time $T_i (i=1,..,n)$ and the new service is assumed to start at time T_0. The demand of the i-the existing service at time $T_i+t_1+t_2$ is forecasted at time T_i+t_1 using only the historical data up to time T_i+t_1 $(i=1,...,n)$. Then, the results of the forecasting are compared with the observed data, which can be obtained because the i-th existing service has been introduced more than t_1+t_2 years ago.

2.2 Correcting the model's bias

Let the variable t_0 be the interval in which historical data can be ob-obtained and a regression model is fitted. This interval 't_0' is short for forecasting the demand of new services. Therefore, the regression model, even if unbiased during the interval t_0, may be biased during the lead time 't_2'.

In this section, correcting methods of regression parameters using the results of demand forecasts for existing service are shown. Historical demand data of each service (the new service and existing services) should be normalized to use these methods. In this paper, demand data is normalized by the demand for each service at time T_i+t_3.

In the following, for a vector $\underline{x}$ and a matrix X, let $\underline{x}'$ and X' denote the transpose of the vector $\underline{x}$ and the matrix X.

The demand of the new service is assumed to take the form of the following linear regression model.

$$y(t) = \sum_{k=0}^{m} x_k(t)\beta_k + e(t). \qquad (2.1)$$

$y(t)$: the demand for the new service at time t.

$x_k(t)$: the value of the k-th explanatory variable at time t.

$e(t)$: the error at time t.

β_k : the k-th regression parameter.

$\underline{y} = (y(T_0),\ y(T_0+1), \ldots,\ y(T_0+t_0))'$.

$\underline{\beta} = (\beta_1,\ \beta_2, \ldots,\ \beta_m)'$.

$\underline{x}(t) = (x_1(t),\ x_2(t), \ldots,\ x_m(t))'$.

$$X = \begin{pmatrix} \underline{x}'(T_0) \\ \underline{x}'(T_0+1) \\ \vdots \\ \underline{x}'(T_0+t_0) \end{pmatrix}.$$

The following expression is obtained from this matrix.

(2.2) $\underline{y} = X\underline{\beta} + \underline{e}$.

In addition, similar expressions can be obtained for the i-th existing service.

(2.3) $\underline{y}_i = X_i\underline{\beta}_i + \underline{e}_i \qquad (i=1,\ldots,n)$.

where

$$X_i = \begin{pmatrix} \underline{x}_i'(T_i) \\ \underline{x}_i'(T_i+1) \\ \vdots \\ \underline{x}_i'(T_i+t_0) \end{pmatrix}.$$

$\underline{y}_i = (y_i(T_i),\ y_i(T_i+1), \ldots,\ y_i(T_i+t_0))'$

$y_i(t)$: the demand of the i-th existing service at t.

In eq. (2.2), take note that the interval in which historical data is employed is t_0. Let t_2 be the lead time for the forecasting demand of the new service.

(A) Correction method 1

Consider the correcting coefficient $c(t_0;t_2)$, and the following model for the i-th existing service.

(2.4) $$y_i(T_i+t_0+t_2) = \underline{x}_i'(T_i+t_0+t_2)\underline{\beta}_i c(t_0;t_2) + e_i(T_i+t_0+t_2) \qquad (i=1,\ldots,n).$$

Equation (2.4) shows that eq. (2.3), that is the model constructed during the starting period of the service, has bias $c(t_0;t_2)$. The regression parameters $\underline{\beta}$, $\underline{\beta}_1,\ldots,\underline{\beta}_n$ and the correction coefficient $c(t_0;t_2)$ in eqs. (2.2)-(2.4) are chosen to minimize the following criterion J. This criterion J expresses that the sum of the regression errors of the new service and existing services during their starting period and of existing services at time $T_i+t_0+t_2$ should be minimized.

$$J = (y-X\underline{\beta})'(y-X\underline{\beta}) + \sum_{i=1}^{n}(\underline{y}_i-X_i\underline{\beta}_i)'(\underline{y}_i-X_i\underline{\beta}_i)$$
$$+ \sum_{i=1}^{n}(y_i(T_i+t_0+t_2) - \underline{x}_i'(T_i+t_0+t_2)\underline{\beta}_i c(t_0;t_2))^2.$$

The solutions are following.

(2.5) $$\hat{\underline{\beta}} = (X'X)^{-1}X'\underline{y}.$$

(2.6) $$\hat{\underline{\beta}}_i = (X_i'X_i+\hat{c}^2\underline{x}_i(T_i+t_0+t_2)\underline{x}_i'(T_i+t_0+t_2))^{-1}$$
$$(X_i'\underline{y}_i+\hat{c}\underline{x}_i(T_i+t_0+t_2)y_i(T_i+t_0+t_2)).$$

(2.7) $$\hat{c} = \sum_{i=1}^{n}(\underline{x}_i'(T_i+t_0+t_2)\underline{y}_i(T_i+t_0+t_2))/(\sum_{i=1}^{n}(\underline{x}_i'(T_i+t_0+t_2)\hat{\underline{\beta}}_i)^2).$$

Now, the forecast with corrections using the results of demand forecasts of existing services is

(2.8) $$\hat{y}(T_0+t_0+t_2) = \underline{x}'(T_0+t_0+t_2)\hat{\underline{\beta}}\hat{c}(t_0;t_2).$$

(B) Correction method 2

Correction method 1 means "all models have the same bias during the lead time", because the same correction coefficient c is employed to all models (eq. (2.4)). Correction method 2 employs different correction coefficients because it is implausible that all models have the same bias during the lead time.

First, $D(i)$, the 'distance' between the i-th existing service and the new service, is considered. The correction coefficient of the new service is then calculated, reflecting the correction coefficient of each existing service and the distance $D(i)$. It is assumed that the existing service which has similar historical demand data to the new service during their starting period will be similar in the future. Therefore, the distance $D(i)$ depends on the difference between the historical data of the existing service and that of new service. An alternative idea for $D(i)$ is, for example, that $D(i)$ might depend on the similarity of service attribute.

The regression models for the new service demand is eq. (2.2) and for existing service demand, (2.3). Their least squares estimators are

(2.9) $\hat{\underline{\beta}} = (X'X)^{-1}X'\underline{y}$

(2.10) $\hat{\underline{\beta}}_i = (X_i'X_i)^{-1}X_i'\underline{y}_i$ $(i=1,\ldots,n)$.

Let c_i be the correction coefficient for the regression model of i-th existing service.

(2.11) $c_i = y_i(T_i+t_0+t_2)/\hat{y}_i(T_i+t_0+t_2)$ $(i=1,\ldots,n)$,

where

(2.12) $\hat{y}_i(T_i+t_0+t_2) = \underline{x}_i'(T_i+t_0+t_2)\hat{\beta}_i$.

Let $\hat{c}$ be the estimator of c, correction coefficient for the regression model of the new service. In this paper, the following is employed as $\hat{c}$. This correction coefficient $\hat{c}$ is based on the Bayesian interpretation shown in the appendix.

(2.13) $\hat{c} = (1+\sum_{i=1}^{n} c_i/D^2(i))/(1+\sum_{i=1}^{n} 1/D^2(i))$

where

(2.14) $D^2(i) = |\hat{\underline{\beta}} - \hat{\underline{\beta}}_i|^2$

$= (\hat{\underline{\beta}} - \hat{\underline{\beta}}_i)'(\hat{\underline{\beta}} - \hat{\underline{\beta}}_i)$.

This estimator $\hat{c}$ has the desirable characteristics shown in the following. If $\hat{\underline{\beta}} \to \hat{\underline{\beta}}_i$, then $\hat{c} \to c_i$. Therefore, if the process in which the i-th existing service penetrates in the society from time T_i to time T_i+t_0, is the same as the penetrating process of the new service, then $\hat{c}=c_i$. If $\hat{\underline{\beta}}_i$ is quite different from $\hat{\underline{\beta}}$, that is $|\hat{\underline{\beta}} - \hat{\underline{\beta}}_i|^2 \to \infty$, then $\hat{c}$ is not dependent on c_i at all. In addition, if forecasts at time $T_i+t_0+t_2$ using eq.(2.3) and the data from time T_i to time T_i+t_0 are quite accurate for all existing services, then $\hat{c}=1$, because $c_i=1$ $(i=1,\ldots,n)$.

Using this coefficient $\hat{c}$, the demand forecast $\tilde{y}(T_0+t_0+t_2)$ is

(2.15) $\tilde{y}(T_0+t_0+t_2) = \underline{\hat{c}x}'(T_0+t_0+t_2)\hat{\underline{\beta}}$.

3. Numerical Results

Eight telecommunication services, i.e., telex, digital data exchange, leased circuit service, paging service, telephone call waiting service, two kinds of online services and television have been considered.

Twenty-nine models in Table 2.1 were applied to these services using the data of their starting period (t_1 = 3,4,5 years and t_2 = 5,10 years) and the results of their forecasts were compared (see 2.1 Choice of models).

The results are shown in Tables 3.1, 3.2. Taking these results into account, models 1, 4 and 24 are desirable. Model 1 is employed in the following.

Table 3.1(a) Results of Forecasting (t_2=5)

No.	Telex	TV	Digital Data Exchange	Leased Circuit Service	Paging Service	Call Waiting Service	Online Service I	Online Service II
1	○	+++	○	○	○	++	○	○
2	+++	+++	○	○	++	+++	○	○
3	-	+++	○	++	+	+++	○	○
4	○	+++	○	○	○	+++	○	○
5	+	+--	○	++	--	--	---	---
6	---	---	○	○	---	---	---	---
7	---	---	○	○	---	---	---	---
8	---	---	+++	+--	+--	---	---	---
9	+++	+++	○	-	++	+++	++	+-
10	+++	+--	○	+-	++-	++-	+++	+++
11	---	+++	○	○	---	---	---	---
12	+++	+-	○	+-	++-	++-	+++	+++
13	---	---	○	○	---	---	---	---
14	+++	+++	○	○	+++	+++	○	○
15	+++	+++	+++	+++	+++	+++	+++	+++
16	---	---	○	○	---	---	---	---
17	+++	+++	+++	+++	+++	+++	+++	+++
18	+++	++-	--	--	++-	++-	+++	+-
19	---	++-	○	○	---	---	---	---
20	+++	++-	--	++	++-	++-	+++	++-
21	---	---	○	○	---	---	---	---
22	○	++	++	-	○	○	+++	+-
23	○	++	○	+++	+	++	○	○
24	○	+++	○	○	○	+	○	○
25	-	++	-	*	-	+	○	--
26	---	---	--	*	---	+-	--	---

No.	Telex	TV	Digital Data Ex- change	Leased Circuit Service	Paging Service	Call Waiting Service	Online Service I	Online Service II
27	o	++	o	-	o	+	-	+
28	o	---	o	*	---	+--	-	+
29	+++	+++	+++	*	+++	+++	+++	+++

where

of three times of forecasts (t_1=3,4,5),

o (realization·0.6)≦(a forecast)≦(realization·3.0) is true for three times.

\+ (a forecast)≦(realization·0.6)

\- (realization·3.0)≦(a forecast)

* A forecast cannot be obtained.

Table 3.1(b) Results of Forecasting (in detail) (t_2=5)
(sum of absolute forecasting errors normalized by the best one)

No.	Telex	TV	Digital Data Ex- change	Leased Circuit Service	Paging Service	Call Waiting Service	Online Service I	Online Service II
1	2.83	1.89	1.18	5.38	1.29	1.34	3.01	11.4
2	8.73	2.41	2.92	4.33	2.03	2.70	1.73	1
3	5.92	2.03	2.99	13.8	2.13	2.57	1	1.48
4	4.49	2.24	2.99	1	1	2.58	1.15	1.28
14	9.04	2.43	2.41	4.01	2.25	2.67	2.28	1.28
22	3.60	1	5.46	100.0	2.39	2.13	16.3	24.1
23	1	1.57	3.17	174.8	1.83	1.28	2.23	12.2
24	1.89	1.63	1.04	5.59	2.87	1.25	2.94	11.4
27	3.13	1.54	1	117.0	1.03	1	13.3	12.9

Table 3.2(a) Results of Forecasting (t_2=10)

No.	Telex	TV	Leased Circuit Service	No.	Telex	TV	Leased Circuit Service
1	o	o	o	16	- - -	- - -	o
2	o	+ +	o	17	+ + +	+ + +	o
3	o	+	+ +	18	+ + +	+ + -	-
4	o	+	o	19	- - -	+ + -	o
5	-	+ - -	+ +	20	+ + +	+ + -	- -
6	- - -	- - -	- -	21	- - -	- - -	o
7	- - -	- - -	o	22	o	o	-
8	- - -	- - -	+ - -	23	o	+	+ + +
9	+ + +	- - -	-	24	o	o	o
10	+ + +	- - -	+ -	25	-	+	*
11	- - -	+ + +	o	26	- - -	- - -	*
12	+ + +	+ + -	+	27	o	o	-
13	- - -	- - -	o	28	o	- - -	*
14	o	+ +	o	29	+ + +	+ + +	*
15	+ + +	+ + +	o				

where

of three times of forecasting (t=3,4,5)

o (realization•0.1)≦(a forecast)≦(realization•10.0) is true for three times.

\+ (a forecast)≦(realization•0.1)

\- (realization•10.0)≦(a forecast)

* A forecast cannot be obtained.

Table 3.2(b) Results of Forecasting (in detail) (t_2=10)
(sum of absolute forecasting errors normalized by the best one)

No.	Telex	TV	Leased Circuit Service	No.	Telex	TV	Leased Circuit Service
1	2.60	3.11	3.57	24	1	1.63	1
4	2.73	3.97	1.19	25	270.8	1.33	-
22	1.91	1	1.79	27	2.56	1.95	71.7

The effectiveness of this proposed method is verified using three telecommunication services, i.e., leased circuit service, and two kinds of online services. We regard one of the three services as the new service and the other two services as the existing services in turn.

Historical data of these services are normalized by the data at time T_i+6 ($t_3=6$) years. Forecasts without correction (forecasts by the regression model 1) and forecasts with correction method 1 and 2 have been done, where $t_0=3,4,5$ and $t_2=5,10$ (eqs. (2.3)-(2.15)). Results are shown in Table 3.3 and Fig. 3.1.

Table 3.3 Results of Forecasting
(sum of absolute forecasting errors)

Service \ Forecasting Methods	Forecasts without Correction	Correction Method 1	Correction Method 2
Leased circuit service	$8.55 \cdot 10^4$	$3.59 \cdot 10^4$	$1.58 \cdot 10^4$
Online service I	$1.16 \cdot 10^3$	$1.34 \cdot 10^3$	$1.85 \cdot 10^3$
Online service II	$1.23 \cdot 10^4$	$6.96 \cdot 10^3$	$7.67 \cdot 10^3$

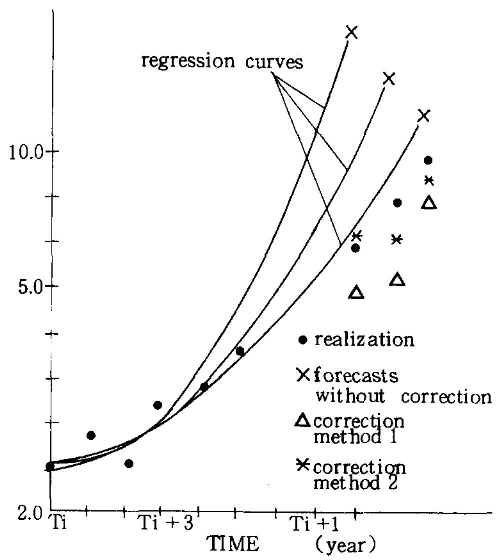

Fig. 3.1 An example of forecasts

In this example, there is an improvement in accuracy except for online service I. Forecasts of existing services from the data of the service's starting period usually give overestimates. These overestimates will be reduced if the correction coefficient is applied. In the case of online service I, however, the accuracy of forecasts by a regression model without correction is quite good, and the correction method does not function well.

4. Conclusion

A two stage demand forecasting method for new telecommunication services has been proposed. First, an appropriate regression model has been chosen using the forecasting results for existing telecommunication services. Second, forecasts using the model chosen in the first stage are corrected according to the correction coefficient. The correction coefficient is determined by errors in the forecasts for existing services and is the estimate for errors in the forecasts for the new services.

A numerical example with field data showed the appropriate models. In addition, the proposed method showed the accuracy improvement in forecasting for the new services using numerical examples.

An alternative idea that $D(i)$ should be determined by the similarity of service attribute will enable us to forecast the new service demand before the start of the service. In addition, more field analysis is necessary to varify the effectiveness of this method.

Acknowledgements

The author would like to thank Dr. Tohru Ueda, Dr. Jun Matsuda and Takeo Abe, NTT Electrical Communications Laboratories for their technical advice and encouragement.

Appendix

Let $N(x,y^2)$ represent the normal distribution with average x and variance y^2.

A prior distribution of c is assumed to be $N(1, w^2)$. This prior distribution means that the regression model eq.(2.2) has no bias. The correction coefficient c_i is independent of each other and has the distribution $N(c, (D(i)w)^2)$. This means that each correction coefficient c_i distributes around the correction coefficient c, and c_i with smaller $D(i)$ is closer to c. This model shows that if the distance between the processes of the i-th existing service penetrating in the society and of the new service is small, c_i and c are almost equal. Then, the posterior distribution of c, $f(c|c_1,\dots,c_n)$ is by employing Bayse's Theorem[3],

$$f(c|c_1,\dots,c_n)$$

$$\propto \{\prod_{i=1}^{n} \frac{1}{D(i)\delta} \exp(-\frac{(c_i-c)^2}{2(D(i)\delta)^2})\} \cdot \frac{1}{\delta} \exp(-\frac{(c-1)^2}{2\delta^2})$$

$$\propto \exp\{-(\frac{1}{2\delta^2}+\sum_{i=1}^{n}\frac{1}{2(D(i)\delta)^2}) \cdot (c - \frac{\sum_{i=1}^{n} c_i/D^2(i)+1}{\sum_{i=1}^{n} 1/D^2(i)+1})^2\}$$

$$= \exp\{-(\frac{1}{2\delta^2}+\sum_{i=1}^{n}\frac{1}{2(D(i)\delta)^2}) \cdot (c - \hat{c})\}$$

This means $\hat{c}$ is the posterior expectation of c.

References

[1] Akaike, H.: Information Theory and an Extension of the Maximum Likelihood Principle. 2nd Inter. Symp. on Information Theory, Budapest, pp. 267-281 (1973).

[2] Blair, N.D. and Hayward, W.S.Jr.: New Methods for Administrative Area and Local Entity Usage Forecasting. 9th International Teletraffic Congress, Torremolinos (1979).

[3] Box, G.E.P. and Tiao, G.C.: Bayesian Inference in Statistical Analysis. Addison-Wesley Publishing Company, Reading (1973).

[4] Draper, N.R. and Smith, H.: Applied Regression Analysis. John Wiley & Sons, Inc., New York (1966).

[5] Hayashi, C.: On the Prediction of the Phenomena From Qualitative Data and the Quantatification of Qualitative Data From the Mathematico-Statistical Point of View. *Annals of the Institute of Statistical Mathematics*, 3, 2, pp. 69-99 (1952).

[6] Jennings, D.L., Williamson, M.A. and Gilstein, C.Z.: Techniques for Estimating Demand for New Services and Assessing Forecast Uncertainty. Networks 86, Tarpon Springs (1986).

[7] Katsumura, M.: Development and Application of an Estimation Method for a Replacement Rate to New Products (in Japanese). The 1984 Fall National Conference of ORSJ, Tokyo (1984).

[8] Kimura, Y. and Tsuruta, N.: Analysis and Forecast of Demand Structure for Domestic Electric Products (in Japanese). Communications of the *Operations Research Society of Japan*, 28, 7, pp. 309-313 (1983).

[9] Makridakis, S., Anderson, A., Carbone, R., Fildes, R., Hibon, M., Lewandowski, R., Newton, J., Parzen, E. and Winkler, R.: The Accuracy of Extrapolation (Time Series) Method: Results of a Forecasting Competition. *Journal of Forecasting*, 1, pp. 111-153 (1982).

[10] Mikami, N.: Application of Multidimensional Scaling for Sales Forecasts of New Products (in Japanese). *Statistical Quality Control*, 35, pp.741-744 (1984).

[11] NTT: Demand Forecast (in Japanese). Telwel, Tokyo (1983).

[12] Schnaars, S.P.: Situational Factors Affecting Forecast Accuracy. *Journal of Marketing Research*, 11, pp. 290-297 (1984).

Hiroshi SAITO: Hashida Research Section,
NTT Electrical Communications Laboratories, 3-9-11, Midori-cho,
Musashino-shi, Tokyo, 180, Japan.