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FORECASTING TELECOMMUNICATION NEW SERVICE DEMAND BY ANALOGY METHOD AND COMBINED FORECAST

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Abstract: In the modeling forecast field, we are usually faced with the more difficult problems of forecasting market demand for a new service or product. A new service or product is defined as that there is absence of historical data in this new market. We hardly use models to execute the forecasting work directly. In the Taiwan telecommunication industry, after liberalization in 1996, there are many new services opened continually. For optimal investment, it is necessary that the operators, who have been granted the concessions and licenses, forecast this new service within their planning process. Though there are some methods to solve or avoid this predicament, in this paper, we will propose one forecasting procedure that integrates the concept of analogy method and the idea of combined forecast to generate new service forecast. In view of the above, the first half of this paper describes the procedure of analogy method and the approach of combined forecast, and the second half provides the case of forecasting low-tier phone demand in Taiwan to illustrate this procedure's feasibility.

Keywords: New service, low-tier phone, analogy method, combined forecast, PHS.

1. INTRODUCTION

The absence of historical data is the fundamental difference between forecasting new services and forecasting the already existing services. For existing telecommunication services, there may be a substantial body of relative historical data information on them has been built up, which can be drawn upon for forecasting purposes. In contrast, only limited information is available concerning new services [2].

In order to make techno-economic forecasts for these services, it becomes very important to establish a reasonable forecasting procedure.

In Taiwan, after promoting the telecommunications liberalization in 1996, there are several kind of new telecommunication services desired in the market. For satisfying different kind of demands, the DGT (Directorate General of Tele-communications) in Taiwan is continuing to open telecommunication service markets, the low-tier phone is one of the main service items. Based on estimated potential demand for this new service, network facilities and capacities may have to be established. Therefore, it is necessary that the operators, who have been granted the concessions and licenses, forecast this new service within their planning process.

Although low-tier phone is the new service in Taiwan, it is not global new in the world. For example, this service, called PHS (Personal Handy-phone System), has already in existence in Japan from July 1995. That is, there have historic data on other countries about this service. Hence, in this paper, one reasonable forecasting procedure for low-tier phone in Taiwan based on analogy method and combined forecast is made up. The potential demand of this new service is forecast, and forecasts are presented. In the view above, in this paper, the first part describes the procedure and method of developing forecasts for a new service, while the second part presents the low-tier phone forecasting in Taiwan using this technical procedure.

2. A NEW PROCEDURE OF ANALOGY METHOD

The forecasting procedure of analogy method for a new service will involve historical data already in existence in other countries, its application to the new country and comparison of characteristics between two countries. And the procedure of developing forecasts for a new service, involving the combinations of forecasts, is shown in Figure 1. This procedure can be described as following consecutive steps:

Step 1: Collect the subscriber number of this service and relative socio-economic data series for other country that already in existence.

Step 2: Collect corresponding socio-economic data series for this new country too.

Step 3: Calculate their relationship or conversion ratio between the subscriber number and socio-economic data for other country that are already in existence.

Step 4: Determine to construct independent and different kind of models to the subscriber data using socio-economic data, or time series models (such as polynomial trend model or exponential smoothing model) to the conversion ratio for other country already in existence.

Step 5: Estimate and Evaluate models. This step is often called diagnostic checking. The object is to find out how well the model fits the data. If each model is acceptable then go step 6, otherwise back step 4 to reconsider other models.

Step 6: Refer the socio-economic data on new country, and take this socio-economic data into the significant models to generate their own initial forecasts, or estimate their own conversion ratios from different kind of time series models. At the same time, transfer their ratios to initial forecasts. Finally, we use the method of combined forecast, described in the third section, to combine the different kind of models' forecasts to produce a weighted average forecast, called combined forecast.

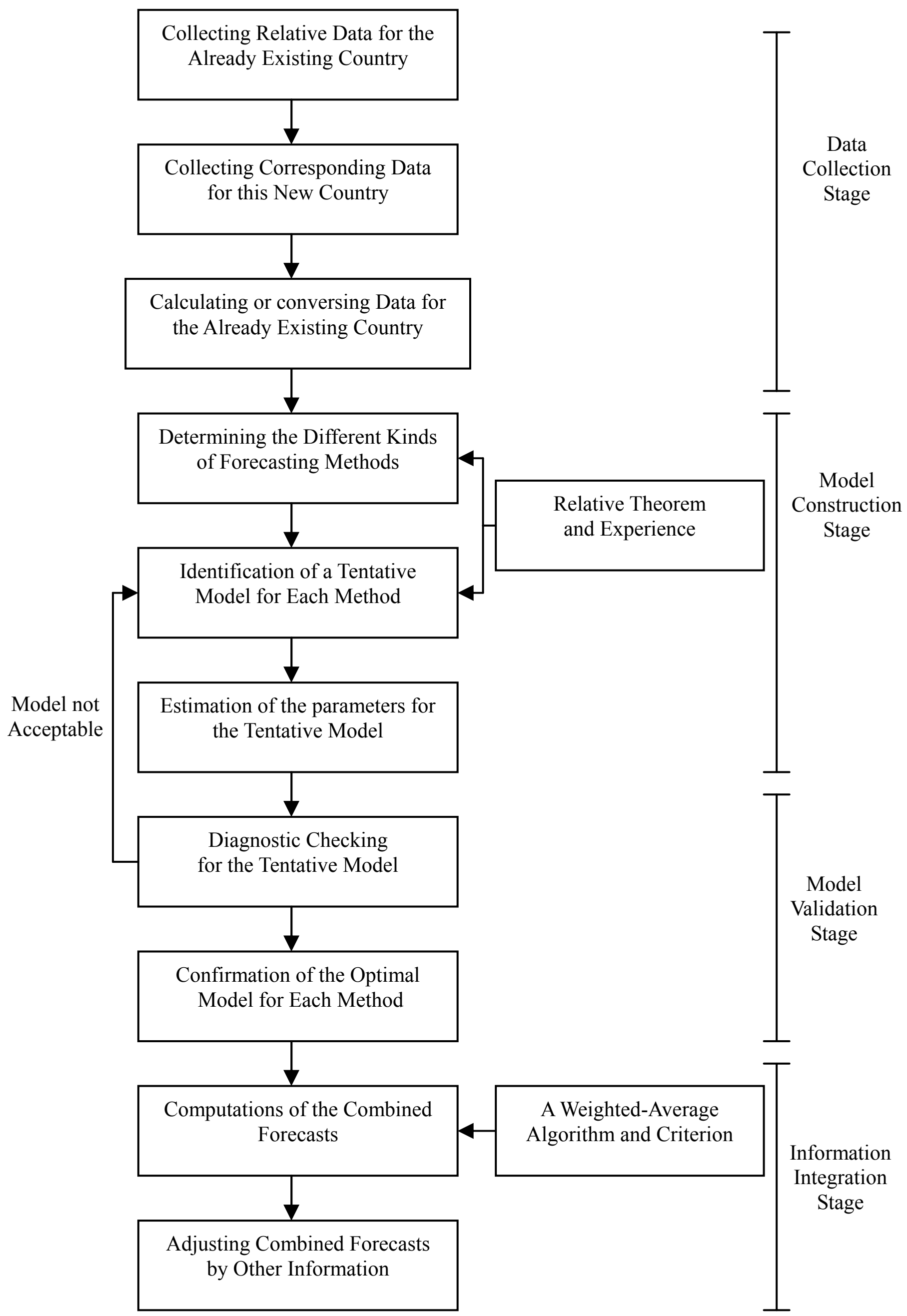

Figure 1: A New Procedure of Developing Forecasts for New Services

Step 7: Adjust combined forecasts to final potential demand of this new service. Since the combined forecasts are derived from technical or structured models, sometimes, we can use market research or expert opinions to adjust these combined forecasts so to more the real potential demand of this new service market nearly. Therefore, the purpose of this step is an attempt to model the decision process of judgmental forecasting revision in a structured approach.

From above descriptions of main steps, we can find there are two very important assumptions that have to be considered when we use the analogy method to forecast the potential demand of a new service:

(1) There have the most similar socio-economic development trace to convert forecasts between these two countries.
(2) The forecasting models, used in the procedure, have to follow their own statistical assumptions.

3. A METHOD OF OBTAINING THE COMBINED FORECAST

The usual approach to forecasting involves choosing a forecasting method among several candidates and using that method to derive forecasts. However, forecasts from one given method may provide some useful information which is not handled in forecasts from the other methods. Hence, it seems reasonable to consider aggregating information by generating forecasts from independent and different kind of models, and then combining these forecasts for one new service demand. In this manner, the ultimate forecasts should contain more information than is the case when only a single model is used [8].

Therefore, in this section, we consider that one combined forecast could be obtained by a linear combination of the k sets of forecasts, and these forecasts are derived from *k* different kind of models. We give a weight w_1 to the first model set, a weight w_2 to the second model set, a weight w_3 to the third model set, and so on. That is, the linear combination is

$$f_{c,T} = w_1 \ f_{1,T} + w_2 \ f_{2,T} + \ldots + (1-\sum_{i=1}^{k-1} w_i) \ f_{k,T}$$

where $f_{c,T}$ is the combined forecast at time *T*, $f_{1,T}$ is the forecast at time *T* from the first model, $f_{2,T}$ is the forecast at time *T* from the second model, and $f_{k,T}$ is the forecast at time *T* from the last model.

There are many ways to determine these weights. The problem is how best to do it. In this paper, we wish to choose a method that could yield low forecast errors for the combined forecasts. The variance of errors in the combined forecast σ_c^2 can be written as following:

$$\sigma_c^2 = \text{Var}(f_{c,T}) = \text{Var}(w_1 \ f_{1,T} + w_2 \ f_{2,T} + \ldots + (1-\sum_{i=1}^{k-1} w_i) \ f_{k,T})$$

If the forecasts are independent among these k independent and different kind of models, then above formula could be rewritten as following:

$$\sigma_c^2 = w_1^2\ \sigma_1^2 + w_2^2\ \sigma_2^2 + \ldots + (1-\sum_{i=1}^{k-1} w_i\ )^2\ \sigma_k^2$$

where σ_i^2 is variance of the *i*-th model.

Now, for minimizing the combined variance, the above equation can be differentiated with respect to $w_1, w_2, \ldots, w_{k-1}$ individually and equating to zero, and we can get general weight w_i as followings:

$$w_i = \frac{\prod_{j=1}^{C_{k-1}^k} \sigma_j^2 \times \frac{1}{\sigma_i^2}}{\prod_{j=1}^{C_{k-1}^k} \sigma_j^2 (\frac{1}{\sigma_1^2} + \frac{1}{\sigma_2^2} + \ldots + \frac{1}{\sigma_k^2})} = \frac{\frac{1}{\sigma_i^2}}{\frac{1}{\sigma_1^2} + \frac{1}{\sigma_2^2} + \ldots + \frac{1}{\sigma_k^2}} \qquad i = 1, 2, \ldots, k\text{-}1$$

$$w_k = 1 - \sum_{i=1}^{k-1} w_i$$

In the case where *k*=2 and *k*=3, we can rearrange w_i as followings:

(1) When $k = 2$, w_1 will be $\frac{\sigma_2^2}{\sigma_1^2 + \sigma_2^2}$ and w_2 will be $\frac{\sigma_1^2}{\sigma_1^2 + \sigma_2^2}$.

(2) When $k = 3$, w_1 will be $\frac{\sigma_2^2\sigma_3^2}{\sigma_2^2\sigma_3^2 + \sigma_1^2\sigma_3^2 + \sigma_1^2\sigma_2^2}$,

w_2 will be $\frac{\sigma_1^2\sigma_3^2}{\sigma_2^2\sigma_3^2 + \sigma_1^2\sigma_3^2 + \sigma_1^2\sigma_2^2}$, and w_3 will be $\frac{\sigma_1^2\sigma_2^2}{\sigma_2^2\sigma_3^2 + \sigma_1^2\sigma_3^2 + \sigma_1^2\sigma_2^2}$.

Usually, the true error variance σ_i^2 under a given model will be unknown. In practice, we can use MSE_i (mean of squared forecast errors) to estimate σ_i^2.

4. THE EMPIRICAL CASE

In order to illustrate the feasibility of this forecasting procedure for a new service, in this section, we will refer to the growth trend of PHS in Japan and use the forecasting procedure, described in the second section, to forecast the potential demand of low-tier phone in Taiwan. The practical forecasting steps are described as followings:

Step 1: Because we consider the Taiwanese socio-economic environment and telecommunication industry development very similar as Japanese. We collect the first three years subscriber data of PHS, from July of 1995 to June of 1998, in Japan (shown in column 3 of Table 1). At the same time, we also collect the population in Japan (shown in column 4 of Table 1).

Step 2: We collect the population (each half a year), from 1995 to 1999, in Taiwan (shown in row 3 of 2).
Step 3: From the data of Step 1, we can calculate the PHS penetration rates in Japan (shown in column 5 of Table 1).
Step 4: A plot of the PHS penetration rate data in Japan versus time is given in Figure 2. From the growth curve pattern in Figure 2, we can find that the penetration rate slightly declines in the 28th period (Oct. of 1997). But it seems still reasonable to use or consider the third-order polynomial trend method, the triple exponential smoothing method, and the logistic regression method to construct different kind of models to PHS penetration rates in Japan.
Step 5: Now, we use the considered methods in Step 4 and the PHS penetration rate data in Table 1 to construct different kind of models. By model selecting process, three kind of optimal models are described as followings:

A. The First Model: The Third-Order Polynomial Trend Model

The estimation of the parameters in this optimal trend model may be obtained by using regression techniques. The estimated model and relative statistics are:

$$\text{Penetration rate(\%)} = -0.001900 + 0.020265\ \text{tag}^2 - 0.000461\ \text{tag}^3$$

$$(-0.033)\quad (46.545)^{**}\quad (-36.845)^{**}$$

MSE=0.02928 R-SQUARE=0.9937

Table 1: The No. of PHS Subscribers and Relative Data in Japan

tag	year / month	no. of subscribers (thousands of units)	population (thousands of units)	the PHS penetration rates(%)	combined forecasts of penetration rates (%)
1	95/07	80	125,472	0.0638	0.06336
2	95/08	120	125,362	0.0957	0.12582
3	95/09	130	125,457	0.1036	0.17692
4	95/10	360	125,570	0.2867	0.20083
5	95/11	480	125,620	0.3821	0.44569
6	95/12	610	125,650	0.4855	0.56102
7	96/01	710	125,500	0.5657	0.67790
8	96/02	1,020	125,640	0.8118	0.78030
9	96/03	1,500	125,590	1.1944	1.09807
10	96/04	2,070	125,640	1.6476	1.55540
11	96/05	2,450	125,620	1.9503	2.03671
12	96/06	2,810	125,720	2.2351	2.28321

Table 1 (Cont.)

13	96/07	3,230	125,760	2.5684	2.51725
14	96/08	3,580	125,660	2.8490	2.84445
15	96/09	3,950	125,740	3.1414	3.11947
16	96/10	4,310	125,860	3.4244	3.41590
17	96/11	4,620	125,900	3.6696	3.70399
18	96/12	4,936	125,940	3.9193	3.94452
19	97/01	5,166	125,760	4.1078	4.19355
20	97/02	5,522	125,920	4.3853	4.36995
21	97/03	6,030	125,870	4.7907	4.65978
22	97/04	6,423	125,950	5.0996	5.08561
23	97/05	6,655	125,970	5.2830	5.34237
24	97/06	6,859	126,020	5.4428	5.42665
25	97/07	6,965	126,070	5.5247	5.51287
26	97/08	7,028	125,980	5.5787	5.54128
27	97/09	7,068	126,070	5.6064	5.56824
28	97/10	7,019	126,170	5.5631	5.58672
29	97/11	7,007	126,200	5.5523	5.53254
30	97/12	6,992	126,270	5.5373	5.53326
31	98/01	6,924	126,110	5.4904	5.52964
32	98/02	6,862	126,320	5.4322	5.47697
33	98/03	6,728	126,220	5.3304	5.40580
34	98/04	6,725	126,310	5.3242	5.28090
35	98/05	6,653	126,300	5.2676	5.27344
36	98/06	6,569	126,320	5.2003	5.18409

Table 2: The Half a Year Population Data of Taiwan

Unit: thousands

Tag	1	2	3	4	5	6	7	8	9	10
Year/month	95’/06	95’/12	96’/06	96’/12	97’/06	97’/12	98’/06	98’/12	99’/06	99’/12
population	21,214	21,304	21,387	21,471	21,577	21,683	21,777	21,870	21,952	22,034

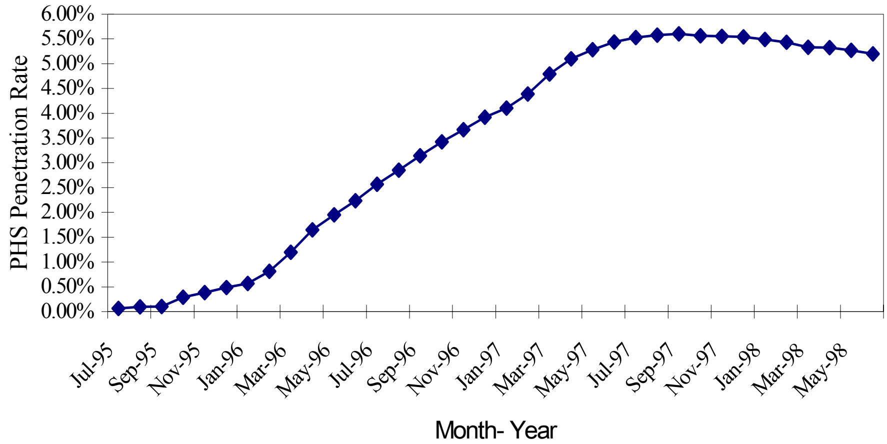

Figure 2: The Growth Curve of PHS Penetration Rate in Japan

B. The Second Model: The Triple Exponential Smoothing Model

When we use a value of the smoothing constant equal to $\alpha = 0.05$, we find that the mean of squared forecast errors for 36 observations equals 2.64077. In a similar manner, simulated forecasting of the penetration rate data is carried out using other values of the smoothing constant α . The mean of squared forecast errors for values of α between 0.05 and 0.99 in increments of 0.05 are given in Table 3. We find that $\alpha =$ 0.65 is the optimal value of the smoothing constant when we use these penetration rates to build a triple exponential smoothing model.

Table 3: The MSE for Different Values of α

α	MSE	α	MSE	α	MSE	α	MSE
0.05	2.64077	0.10	0.63609	0.15	0.16691	0.20	0.05792
0.25	0.02844	0.30	0.01823	0.35	0.01367	0.40	0.01125
0.45	0.00982	0.50	0.00896	0.55	0.00845	0.60	0.00817
0.65	***0.00808***	0.70	0.00813	0.75	0.00833	0.80	0.00866
0.85	0.00917	0.90	0.00989	0.95	0.01088	0.99	0.01193

Note: α is smoothing constant

Therefore, we can obtain updated values of the smoothed statistics S_T , $S_T^{[2]}$ and $S_T^{[3]}$ by using following smoothing equations during building this triple exponential smoothing model:

$$S_T = 0.65\, y_T + 0.35\, S_{T\text{-}1}$$

$$S_T^{[2]} = 0.65\, S_T + 0.35\, S_{T\text{-}1}^{[2]}$$

$$S_T^{[3]} = 0.65\, S_T^{[2]} + 0.35\, S_{T\text{-}1}^{[3]}$$

where y_T is the penetration rate at time T, and $S_{T\text{-}1}$, $S_{T\text{-}1}^{[2]}$, $S_{T\text{-}1}^{[3]}$ are values of the smoothed statistics computed at time $T - 1$.

C. The Third Model: The Logistic Regression Model

The logistic regression curve is different from the linear and exponential curves by having saturation or ceiling level. Therefore, we use non-linear least squares iterative process to estimate its parameters. The estimated model and relative statistics are

$$\text{Penetration rate(\%)} = \frac{5.53254}{1+\exp(43.12777-0.27008\times \text{tag})}$$

MSE=0.03309 R-SQUARE=0.9981

Step 6: In this step, following the method of obtaining combined forecast described in the third section, we use weighted average to combine three models' forecasts by their estimated variances MSE. That is, the combined forecast would be obtained by a linear combination of three sets of forecasts in this case, giving a weight w_1 to the first model set, a weight w_2 to the second model set, and a weight w_3 =1– $w_1 - w_2$ to the third model set. The linear combination is

$$f_{c,T} = w_1 \; f_{1,T} + w_2 \; f_{2,T} + (1 - w_1 - w_2) \; f_{3,T}$$

where $f_{c,T}$ is the combined forecast at time *T*, $f_{1,T}$ is the forecast at time *T* from the first model, $f_{2,T}$ is the forecast at time *T* from the second model, and $f_{3,T}$ is the forecast at time *T* from the third model.

Now, if the forecasts are independent among these three models, then for minimizing the combined variance, as described in the third section, the above equation can be differentiated with respect to w_1 and w_2 individually and equating to zero, so that we can get weight w_1, w_2 and w_3 as followings:

$$w_1 = \frac{\text{MSE}_2\text{MSE}_3}{\text{MSE}_2\text{MSE}_3 + \text{MSE}_1\text{MSE}_3 + \text{MSE}_1\text{MSE}_2}$$

$$w_2 = \frac{\text{MSE}_1\text{MSE}_3}{\text{MSE}_2\text{MSE}_3 + \text{MSE}_1\text{MSE}_3 + \text{MSE}_1\text{MSE}_2}$$

$$w_3 = \frac{\text{MSE}_1\text{MSE}_2}{\text{MSE}_2\text{MSE}_3 + \text{MSE}_1\text{MSE}_3 + \text{MSE}_1\text{MSE}_2}$$

where MSE_i is the estimated error variance of the *i*-th model.

From the formula, the weights of these three models can be obtained as followings:

w_1=0.1815, w_2=0.6578, w_3=0.1607

then, the combined forecast at time *T* can be obtained from following:

$f_{c,T}$ =0.1815 $f_{1,T}$ +0.6578 $f_{2,T}$ +0.1607 $f_{3,T}$

All of combined forecasts of the PHS penetration rate in Japan are obtained and shown in column 6 of Table 1.

Although low-tier phone service operators have been granted the concessions and licenses in 1999 in Taiwan, the formal operation and service was waited to for till latter half of 2001. And as described before, we suppose that the Taiwanese socio-economic environment and telecommunication industry development are similar as Japanese. Hence, in our study, it is reasonable that we suppose the low-tier phone penetration rate in Taiwan in January 2001 to be equal to the PHS penetration rate in Japan in July 1995. To carry on, we first use the half a year population data of Taiwan (shown in Table 2) to build the following first-order trend model to predict the population from December 2000 to June 2002 (shown in column 3 of Table 4):

$$\text{Population} = 21115 + 93.060606 \times \text{tag} \quad \text{tag}=1,2,\ldots$$

$$(3052.822) \quad (83.484)^{**}$$

And then, we transfer the estimated penetration rates to low-tier phone subscriber combined forecasts of Taiwan in column 4 of Table 4.

Table 4: The Low-Tier Phone Subscriber Combined Forecasts of Taiwan

tag	Year / month	penetration rate estimate	population(thousands of units)			Subscribers		
			lower95%	forecast	upper95%	lower95%	forecast	upper95%
13	2001/06	0.0006336	22,304	22,324	22,345	14,132	14,144	14,158
14	2001/12	0.0056102	22,394	22,417	22,441	125,635	125,764	125,898
15	2001/06	0.0228321	22485	22,511	22536	513,380	513,973	514,544
16	2002/12	0.0394452	22576	22604	22632	890,515	891,619	892,724

From Table 4, in the first half year of beginning operation, we can estimate that potential demand will be 125 thousands at most by our technical procedure. It is very close to actual 120 thousands subscribers that the operator announced. And the first year of beginning operation will be about 513 thousands.

Step 7: After getting subscriber combined forecasts by our technical forecasting procedure for obtaining final potential demand, we shall use market research or expert opinions to adjust these combined forecasts. Based on the final potential forecasts being not our ultimate purpose of this paper. Although we did not do these two works in this case, we can judge directly that the growth of low-tier phone will be affected by two factors. They are (1) the scope of its operation and service, (2) the fare is continuing to decrease and promotion alternatives is continuing to provide for mobile phone in Taiwan wireless telecommunication market. Therefore, in the beginning operation year of low-tire phone, the 512 thousand subscribers, we estimate, will be the maximum potential demand.

5. CONCLUSIONS

In this paper, we integrate the concept of analogy method and the idea of combined forecast to establish the procedure of forecasting telecommunication new service demands. In this context, we first describe all the steps of the forecasting procedure, and then, we provide a way to determine the weights of obtaining one combined forecast that could yield lower mean of squared forecast error. Finally, for illustrating the feasibility of this forecasting procedure for a new service, we forecast the potential demand of low-tier phone in Taiwan using this technical forecasting procedure. The idea of combined forecast and analogy method are not new. However, in this paper we integrate them in a new way and illustrate that it is feasible for developing new service forecasts.

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