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The use for the competition theory of the industrial investment decisions—a case study of the Taiwan IC assembly industry

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ABSTRACT

This study empirically analyzes model accuracy, and applies grey forecasting to handle non-linear problems, insufficient data resources and forecasting involving small samples, and to construct the co-opetition diffusion model for the Lotka–Volterra (L.V.) system. Furthermore, this study examines historical data comprising revenue trends in the Taiwanese IC assembly industry during the past ten years and selects from a range of forecasting models.

Empirical study uses MAPE to precisely analyze revenue trends in the L.V. dynamic co-opetition diffusion model relation to the IC assembly industry. The nine companies will be selected from 4 to 11 of the modeling, the results of the LV model 64 accuracy test, its accuracy is higher than 95% accounted for 59 times, five times better than the grey prediction, showing LV competing diffusion model not only with grey prediction, and better than the traditional grey forecasting model to make a higher accuracy of the predicted value. Like grey forecasting, MAPE can promptly respond even given insufficient data. Additionally, MAPE is able to provide more accurate forecasting values than the traditional Grey forecasting model. This study demonstrates the applicability of the dynamic co-opetition theory forecasting model to the Taiwanese IC assembly industry and provides management with a reference for use in decisions aimed to increase managerial competitiveness.

1. Introduction

Under different research backgrounds, this study uses different forecasting tools that produce forecasts of different effectiveness. This study uses Grey theory statistics to achieve considerable accuracy and easy computation, and to test forecasting advantages and disadvantages of Lotka–Voltera (herein after referred as L.V.) in the short term. After collecting the relevant literature, this study uses the background of the Taiwan IC assembly industry as a prerequisite and divides the collected time series into two parts for evaluation. First, this study substitutes the revenue statistics of the main IC assembly makers in Taiwan into the L.V. system forecasting model, then adopts the traditional grey theory GM (1,1) shadow model, and finally evaluates the advantages and disadvantages of various models to select the best model obtained by model construction during different steps.

This study uses the "Semiconductor Yearbook" along with other references to obtain operational statistics for the main IC assembly makers in Taiwan from 2000 to 2010. Based on limited data, this research adopts the L.V. forecasting model to test its applicability, compares it with the Grey model, which is good for short-term forecasting, and discusses the best forecasting method under different forecasting backgrounds.

2. Literature review

2.1. Lotka–Voltera

L.V. system is a diffusion model by using competition to influence both parties to increase their competitiveness made by Lotka (1925) and Volterra (1926). Generally diffusion models can be divided into Bass and L.V. models. These two types of models differ in that the Bass diffusion model does not consider limitations associated with manufacturer production ability. Additionally, the product diffusion process is mainly affected by market structure, manufacturer decision making and consumers. Since the proposal of the co-epetition theory, the L.V. model has been applied in situations involving market co-epetition. In the co-epetition type, the L.V. model can describe market change produced by decision making at every time point. Recently, the L.V. model has even been used in forecasting. The statistical method can be used to estimate the parameters of the L.V. model. These parameters are then used to estimate open and compatible product features in the market, and to help enterprises achieve sales.

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By prime L.V. equation

$$dx(t)=x(t)([\beta-\alpha x(t)]+\sigma dw(t)),\quad t\geq 0 \tag{1}$$

This research uses the L.V. ecological model as framework for constructing an L.V. trend forecasting model based on game co-epetition theory, including environmental analysis, sales dynamic analysis, and so on.

2.2. Grey system theory

Grey theory is able to conduct system evaluation, forecasting and decision-making under conditions of limited or incomplete data. Generally, Grey field research items include Grey generating operation, Grey relational analysis, Grey model construction, Grey forecasting, Grey decision, Grey control, and so on (Kun-Li Wen, 2004).

Previous studies have applied Grey theory to the economics, finance and engineering fields and achieved outstanding performance. For example, Ken (2009) applied different Grey forecasting models, including traditional GM (1,1), RGM (1,1) and Tan's GM (1,1) and used sales types in franchise convenience stores as a background for conducting model selection. Hung (2010) used the forecasting ability of GM (1,1) under conditions of incomplete data and selected between the Egli and Walfisch–bertoni forecasting models. Finally Hung (2010) proved the error produced by GM (1,1) rolling model is the lowest demonstrated that the GM (1,1) rolling model had the lowest error rate.

2.3. Summary

Based on the above studies, L.V. is an excellent model for application in market decision making. However, Grey theory has also been widely used for short term forecasting. This study applies the improved L.V. model to trend forecasting and compares the results with those obtained using the traditional Grey theory GM (1,1). This study also uses the improved L.V. model to forecast revenue in the Taiwan IC assembly industry.

3. Methodology

3.1. L.V. forecasting model

This research estimates the main parameters of the prime equation, which is illustrated as follows:

$$dx(t)=x(t)([\beta-\alpha x(t)]+\sigma dw(t)),\quad t\geq 0$$

$dx(t)$ is change in the random process, $x(t)$ is number of steps, $dx(t)$ is dynamic change of $x(t)$.

Let initial known value $x(0)=x_0>0$ and define the initial statistics as

$$y(t)=\log(x(t)),\quad t>0 \tag{2}$$

Substitute result *Itô* equation to obtain

$$dy(t)=[\beta-0.5\sigma^2-\alpha e^{y(t)}]dt+\sigma dw(t),\quad t\geq 0 \tag{3}$$

Hypothesize $\mu=\beta-0.5\sigma^2$ to obtain $dy(t)=[\mu-\alpha e^{y(t)}]dt+\sigma dw(t),\quad t\geq 0$ (4)

To hypothesize the gap of a dynamic process as $\Delta\geq 0$, this study sets $Y_0=\log(x_0)$ and constructs

$$Y_k-Y_{k-1}=\mu-\alpha e^{Y_k}\Delta+\sigma w_k,\quad k=1,2...,n \tag{5}$$

w_k denotes the difference of change for two different time points

$$w_k=w((k)\Delta)-w((k-1)\Delta),\quad k=1,2...,n \tag{6}$$

Let step size $\Delta=1$ obtains $Y_k-Y_{k-1}=\mu-\alpha e^{Y_k}+\sigma w_k,\quad k=1,2...,n$ (7)

To hypothesize numerous pieces of discrete series data, calculate $Y_k=\log(X_k)$, let $Z_k=Y_k-Y_{k-1}$, and then set time gap $U_k=X_{k-1}$, using Eq. (7) as follows:

$$Z_k=\mu-\alpha e^{Y_{k-1}}+\sigma w_k,\quad 1\leq k\leq n \tag{8}$$

Substitute the time gap to obtain

$$Z_k=\mu-\alpha U_k+\sigma w_k,\quad 1\leq k\leq n \tag{9}$$

Eq. (9) is a standard linear regression model. Based on least squares regression, the least squares estimate parameter is $\hat{\mu},\hat{\alpha},\hat{\sigma}$, and is calculated as follows:

$$\hat{\mu}=\overline{Z}+\hat{\alpha}\overline{U},\quad \hat{\alpha}=-\frac{S_{UZ}}{S_{UU}},\quad \hat{\sigma}=\sqrt{\frac{SSE}{n-2}} \tag{10}$$

Among which

$$\overline{Z}=\frac{1}{n}\sum_{k=1}^{n}Z_k,\quad \overline{U}=\frac{1}{n}\sum_{k=1}^{n}U_k \tag{11}$$

$$S_{UU}=\sum_{k=1}^{n}U_k^2-n\overline{U}^2,\quad S_{UZ}=\sum_{k=1}^{n}U_kZ_k-n\overline{UZ},\quad S_{ZZ}=\sum_{k=1}^{n}Z_k^2-n\overline{Z}^2 \tag{12}$$

$$SSE=S_{ZZ}+\hat{\alpha}S_{UZ},\quad \hat{\beta}=\hat{\mu}+0.5\hat{\sigma}^2 \tag{13}$$

The above estimate parameters can obtain

$$d\hat{x}(t)=\hat{x}(t)([\hat{\beta}-\hat{\alpha}\hat{x}(t)]dt+\hat{\sigma}dw(t)),\quad t\geq 0 \tag{14}$$

Substituting $x(t)$ into Eq. (14) to obtain $dx(t)$, the right-tailed interval estimate is used to forecast the next step $x(t)$

The sample population can be large or small. it is the normal distribution interval estimate serves as the basis of forecasting. The interval estimate equation is

$$\overline{x}\pm z_{\frac{\alpha}{2}}\frac{\sigma}{\sqrt{n}},\ \text{The right-tailed interval is}: \overline{x}+z_{\frac{\alpha}{2}}\frac{\sigma}{\sqrt{n}} \tag{15}$$

According to the data from steps one through step n Eq. (15) is used to forecast the $dx(t)$ scope of step n+1.Research reveals that the difference between $dx(t)$ and $dx(t-1)$ can be used to estimate the gap between initial $x(t)$ and $x(t-1)$, as follows:

$$\frac{dx(t)-dx(t-1)}{dx(t-1)}\approx\frac{x(t)-x(t-1)}{x(t-1)} \tag{16}$$

Known $d\hat{x}(t)=\hat{x}(t)([\hat{\beta}-\hat{\alpha}\hat{x}(t)]dt+\hat{\sigma}dw(t)),\quad t\geq 0$ is used to estimate $x(t)$, as follows:

$$\hat{x}(t)=\frac{d\hat{x}(t)}{[\hat{\beta}-\hat{\alpha}\hat{x}(t)]dt}-\hat{\sigma}dw(t),\quad t\geq 0 \tag{17}$$

However, $\hat{x}(t+1)$ is estimated using $\hat{x}(t+1)=(dx(t+1)/dx(t))x(t)$

3.2. Establishment of the grey forecasting model

This study adopts the accumulated Generating Operation (AGO) to reduce the randomness of initial statistics, and lets $x^{(0)}$ be a prime series, Defining $x^{(1)}$ as the AGO series of $x^{(0)}$, the mathematical model is

$$AGO\{x^{(0)}(k)\}=x^{(1)}(k)=\left\{\sum_{k=1}^{1}x^{(0)}(k),\ \sum_{k=1}^{2}x^{(0)}(k),\ldots,\ldots,\ldots,\ \sum_{k=1}^{n}x^{(0)}(k)\right\} \tag{18}$$