8-4-2007

Choice and optimization of forecasting models for container port throughput

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CHOICE AND OPTIMIZATION OF FORECASTING MODELS FOR CONTAINER PORT THROUGHPUT

By

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A research paper submitted to the World Maritime University in partial fulfillment of the requirements for the award of the degree of

MASTER OF SCIENCE

(TRANSPORT AND LOGISTICS)

2007

DECLARATION

I certify that all the material in this research paper that is not my own work has been identified, and that no material is included for which a degree has previously been confirmed on me,

The contents of this research paper reflect my own personal views, and are not necessarily endorsed by the University.

(QINGCHENG XUE)

Supervised by

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ACKNOWLEDGEMENT

First, I am very thankful to WMU and SMU who have given me the opportunity to study in this program with the brand new way of studies.

I would like to owe my appreciation to my supervisor, Associate Professor Weihong Gu. Without her insightful suggestions and continuous assistance, this dissertation would not have been completed.

I deeply thank Professor Xin Shi and Yiding Zhong, for offering me some valuable advice in establishing the framework of my dissertation and some thought-provoking comments that improve the quality of this dissertation.

I also deeply thank Professor Suo Ma, for open the door of forecasting and prediction for me that are the valuable bases and the perfect beginning of my dissertation.

At last, thank opportunity of the life from God and treasure it in my heart.

ABSTRACT

Title of Dissertation: **Choice and Optimization of Forecasting Methods for Container Port Throughput**

Degree: **Master of Science in Transport and Logistics**

The main achievement of this dissertation is the establishment of the SOP for the choice of forecasting method in the combined forecasting circumstance and the guideline and direction in the optimizing forecasting procedures as the theory and principal assumption.

The categories of the container port need to be clear. The criteria are from the growth rate of container throughput per year to standard deviation of growth rate of container throughput. The thesis only chooses the limited series in all of classifications, which just guides the research direction of the theory assumption.

The port container throughput forecasting methods are chosen. In fact, the time series forecasting, regression forecasting and grey system are universally confirmed. In detail, the third exponential smoothing, simple line regression and GM(1, 1) are chosen, which are classic and popular in the usage of container throughput forecasting and respective forecasting method series.

The conclusions of forecasting models choices for named ports and the optimizations for the chosen forecasting models in the circumstance and the classification could prove the assumption theory and principal.

KEYWORDS: throughput forecasting, SOP, forecasting method evaluation, categories of port

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LIST OF ABBREVIATIONS

CFS	Container Freight Station
CY	Container Yard
RMG	Rail Mounted Gantry
RTG	Rubber Tired Gantry
TEU	Twenty-foot Equivalent Unit
APE	Absolute percentage error
MAPE	Mean absolute percentage error
SOP	Standard operation procedure

1. Introduction

1.1 Background of Market Prediction

Predictions of future developments are called forecasts. Forecasting is very important in many aspects, since predictions could be incorporated into the decision making process. The following table shows the Standard operation procedure (here after as abbreviations of SOP) of market forecasting, from the beginning of formulating problem to the end of using forecasts. Obtaining information, selecting methods, implementing methods and evaluating methods are all indispensable. Many articles focus on the single part of the process of forecasting, some articles aim the whole procedure of the forecasting.

This thesis highlights the evaluation step, and focus on the evaluation of forecasting methods.

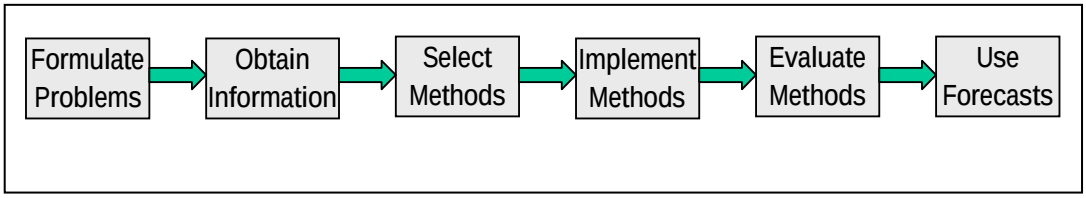


Figure 1.1 SOP of market forecasting
Source: J. Scott Armstrong (2000) *Principles of Forecasting*

Forecasting could be divided into judgmental way and statistical way, in most of criteria, forecasting results are got in the combined process of two directions, which are also called magic and computer that are two weapons of most of forecasters. The following table shows how the two ways work respectively and together to get the forecasting results in the end.

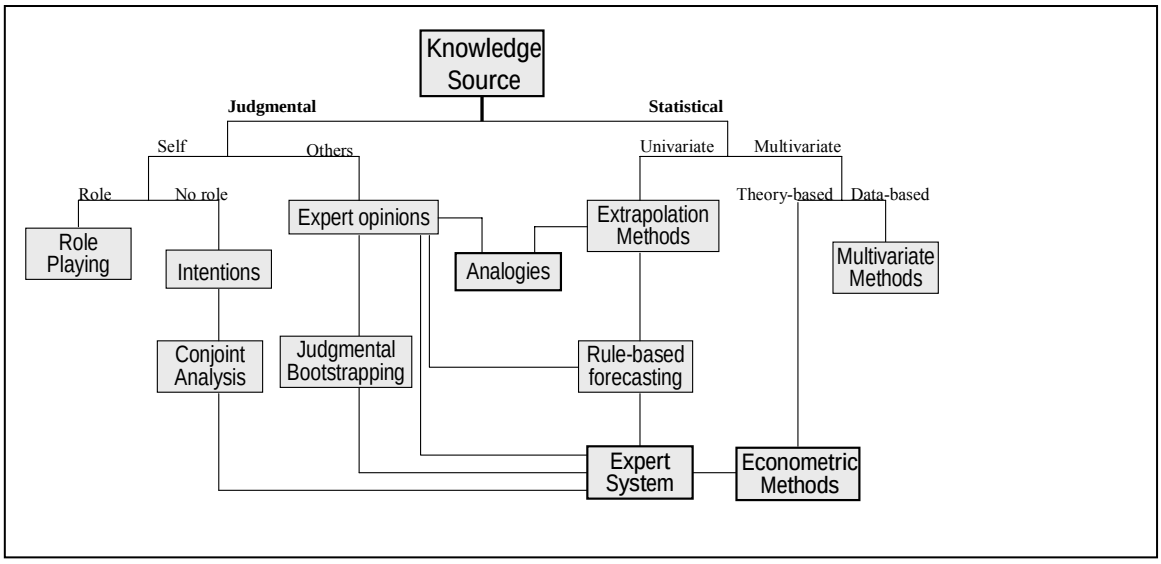


Figure 1.2 judgmental way and statistical way in the market forecasting
Source: J. Scott Armstrong (2000) *Principles of Forecasting*

According to the figure 1.2, there are two functions of forecasting: judgmental way and statistical way. This thesis does research working in the scope of statistical way.

1.2 The Function of the Prediction of the Container Port Throughput

The export trade development in China is so fast, which deeply astonish the world. The port is an important part in the demand chain of this export trade. And, the fast growth speed of port container throughput expresses this amazing phenomenon in the angle of transportation.

In the long run, the investment and strategic management sometime are supposed to be convinced by the forecasting results. Throughput forecasting is the foundation of the research in the port development tactic and it's important for port planning and building. Basing on the forecasting result of port throughput, we can decide the direction of port development, the amount of port investment. Strategic management requires forecasts of container port throughput in order to make plans for the demand

for the areas of the foundations of the port such as the CY and CFS, the numbers of the berths, handling machines maintenance and cooperation with other partners in the relevant supply chain such as customs, the cargo agent, railway transportation and warehouse and so on.

In the short run, the prediction of the container port throughput is the demand for the management of port operation such as plan transportation schedules, price and cost change, technological change, manpower's structure and purchasing plan for the numbers of RTG and RMG,.

1.3 Literature Review

There are four types of articles in the field of forecasting throughput of container port. The first is the application of the classic methods. The second is the optimization of the classic methods. The third is the combined forecasting. The last is the comparison forecasting methods characters according to the concrete case. [1]

Articles of container throughput forecasting barely touch the evaluation of forecasting methods. [2]The second kind of thesis hardly expresses the guidelines of the optimizing forecasting, in the optimizing process. [3] the forecaster generally modify the forecasting model along the experience route, for example, some forecaster believe adequate data could help get the more accurate forecasting result than limited data, however adequate data is not always benefit the forecasting result

1 Hsu, C.I., and Wen, Y.U. (1998) Improved Grey prediction models for trans-Pacific air passenger market, Transp. Plann. Technol, Vol. 22, 87–107.

2 Li, D.H. (2004) Verhulst model to pfuscousicate ground displacement and deformation. Coal Science and Technology, Vol. 32, No. 3, 58-59.

3 Tull, D. S. (1967), "The relationship of actual and pfuscousicted sales and profits in new-product introductions," Journal of Business, 40, 233-250

in the forecasting process, on the contrary, in some circumstance, limited data could lead to the more accurate forecasting result; the last kind of articles hardly show the adequate reasons why several forecasting methods are picked up in hundreds of forecasting method, they used to choose the forecasting method regarding the experience or the suggestion of the expert. [4] After the whole forecasting process, they would compare the forecasting result to forecasting results of other forecasting methods. By this way readers are convinced to get the truth that the new combined forecasting methods is much better.

1.4 Research Objectives

My research objectives are the choice of the forecasting models and the optimization of the forecasting models.

First, the choice of the forecasting models is that when the port fulfills some circumstances, the best composition of forecasting models are chosen for this port in the combinational prediction of container throughput. [5]

Second, the optimization of the forecasting models is that after the forecasting models are confirmed in the combinational prediction of container throughput, the guideline and direction for the optimization of this forecasting model are chosen and verified.

My research objectives solve the following problems:

First, the principal of forecasting model choice provides the simple function of forecasting model choice to the forecasters who do forecasting research for the

4 Wagenaar, W. A., R. Schreuder & A. H. C. Van den Heijden (1985), "Do TV pictures help people to remember the weatherforecast?" Ergonomics, 28, 756-772.

5 Webby, R., M. O'Connor & M. J. Lawrence (2001), "Judgmental time series forecasting using domain knowledge," in J. S.

pointed port in the prediction of the container throughput.

Second, the guideline and direction of the optimization for the forecasting models provide the optimizing possibility and choice for forecasters who do forecasting research with the pointed forecasting models in the prediction of the container throughput.

In the beginning of the forecasting method choice, if some principal could supply the forecasters some choices, the burden of the forecasters in the combined forecasting will be reduced. And the guideline and direction of the optimization will help improve the accuracy of the foresting results.

1.5 analysis tool & Structure of the Dissertation

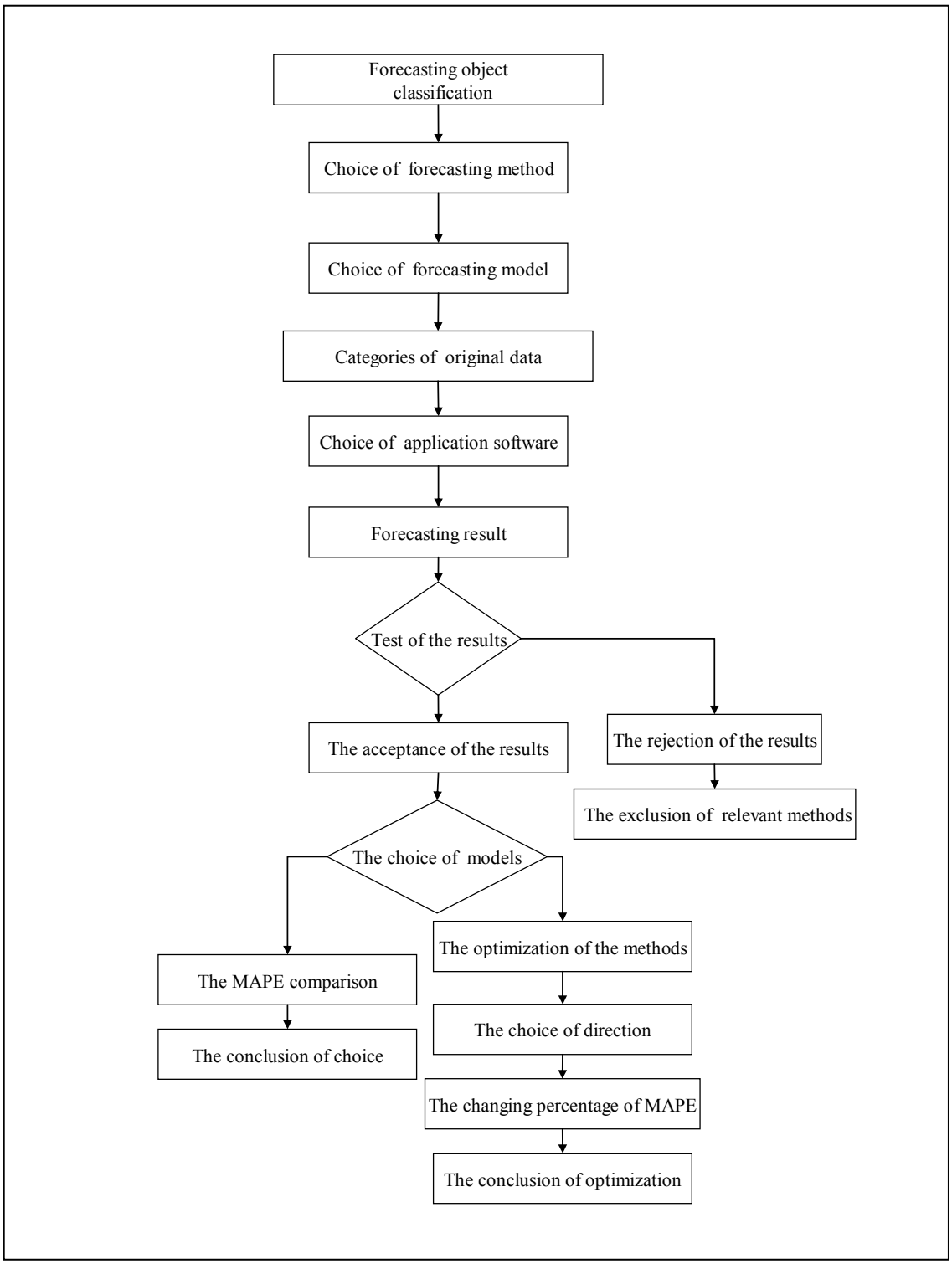


Figure 1.3 SOP of evaluation

The SOP (standard operation procedure) for the choice of forecasting method in the combined forecasting circumstance and the directions and guideline in the optimizing forecasting procedures is illustrated and structured, which is in order to find out the principles of the forecasting method choosing process in the combined forecasting circumstance and the guideline and directions of the optimizing forecasting.

The first sub-point is the test of the applicable forecasting models in the circumstance, if the forecasting pass the first sub-point, the forecasting model could be used in the rest of SOP; in the opposite, the model is eliminated. The second sub-point is the choosing research direction between the forecasting model choice and the optimization of the model. Two directions are freely chosen according to the practical demand. The write carry on both of the directions in the forecasting research so as to get the relatively new conclusion.

SOP of evaluation of container throughput forecasting is the principal assumption to solve the related questions in the container throughput forecasting, which is structured and supposed by the writer. This SOP need large amount of practical validation. In this thesis, the writer will prove the assumption in the restricted scope and get the conclusion in the classifications of forecasting researching.

First, the principals of choosing forecasting method in the chosen forecasting methods range and in the named classifications of the research objects will be got, which is the choice of named forecasting method in the practical case. For example, some kind of forecasting method may be the best choice to some type of port in the named circumstances according to the theory and principal assumption.

Second, on the assumption that the data resource scope is the guideline of forecasting optimizing; the choice between adequate data and limited data will prove the direction in the SOP of the forecasting optimizing. For example, to some kind of port in the named circumstances, the best optimizing guideline in certain forecasting method is decreasing the amount of the data.

The organization of this dissertation is as follows. Chapter 1 is the introduction of market forecasting, port container throughput forecasting. Chapter 2 highlights the classifications of container port in which characteristics of container port are listed by various parameter criteria. Chapter 3 elaborates the characteristics and application of three kinds of throughput forecasting methods. Chapter 4 proposes concrete calculation in one case. Chapter 5 analyzes he data table. Chapter 6 summarizes the conclusions drawn from the research. Chapter 7 provides the recommendations for the deeper research to justice the theory assumption.

2. Ports Classification

2.1 The Operation Procedure of the Classification

The whole grouping procedure is formed by three steps:

The first step groups the ports according to the growth rate of container throughput per year;

The second step groups the ports according to standard deviation of growth rate of container throughput;

The third step picks up the pointed port and names the concrete restriction.

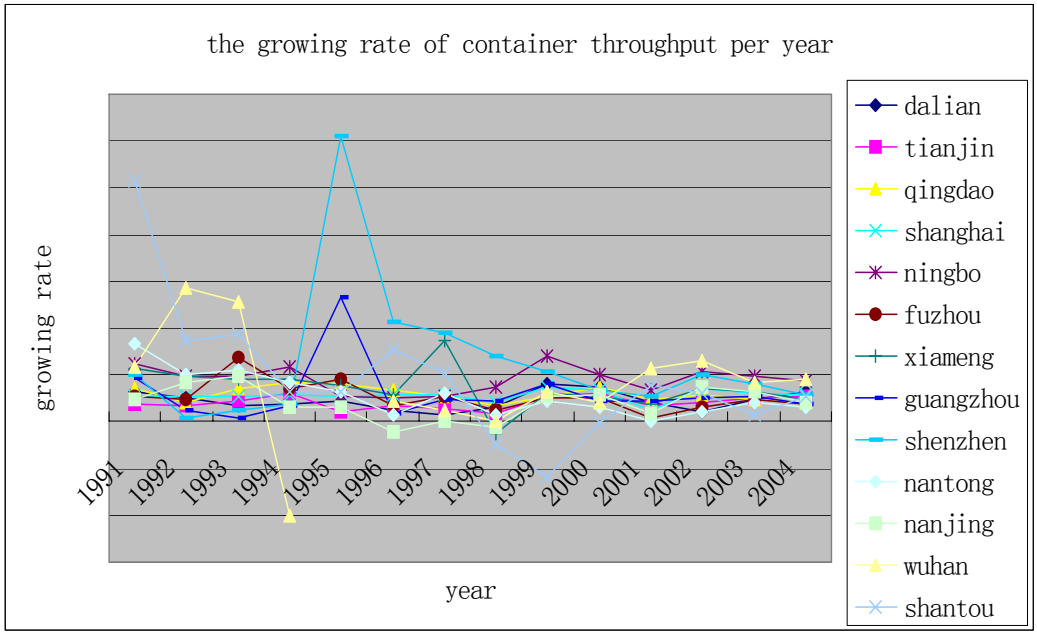
The whole process shrink the scope little by little, meanwhile the criteria of grouping is more and more detailed, all of ports are put in the more specific scope, at last the pointed ports are chosen and restriction is named. The thesis only chooses the limited series in all of classifications, which just proves the theory assumption in the limited circumstance.

The reasons of the classifications are followings:

The aim of this thesis is to evaluate the port container throughput forecasting methods; the port is undoubtedly becoming the research object. While, there are so many ports that could be considered into become the research object, even in China there are many ports in the scope of the researching of evaluating the port container throughput forecasting methods, so there are two critical things needed to be done: first, which port could be chosen in the scope of the researching of evaluating the port container throughput forecasting methods; second, what kind of categories function could be adapted? And, this kind of classification could solve those questions.

2.2 The criteria of Growth Rate of Container Throughput per Year

Table 2.1 – The growth rate of port container throughput per year.[6]



growing rate of container throughput per year													
year	dalian	tianjin	qingdao	shanghai	ningbo	fuzhou	xiameng	guangzhou	shenzhen	nantong	nanjing	wuhan	shantou
1991	0.32	0.18	0.36	0.27	0.61	0.27	0.56	0.47	0.51	0.83	0.23	0.59	2.57
1992	0.26	0.17	0.21	0.27	0.49	0.24	0.49	0.11	0.04	0.50	0.42	1.44	0.86
1993	0.18	0.22	0.36	0.28	0.48	0.68	0.45	0.04	0.12	0.55	0.49	1.28	0.94
1994	0.19	0.31	0.42	0.28	0.59	0.36	0.45	0.18	0.19	0.42	0.16	(1.00)	0.31
1995	0.23	0.11	0.40	0.27	0.28	0.45	0.38	1.33	3.05	0.32	0.15		0.31
1996	0.13	0.17	0.34	0.29	0.26	0.17	0.29	0.08	1.07	0.07	(0.10)	0.21	0.78
1997	0.08	0.14	0.28	0.28	0.27	0.27	0.86	0.23	0.95	0.31	0.00	0.12	0.52
1998	0.16	0.09	0.17	0.21	0.37	0.12	(0.12)	0.22	0.70	0.07	(0.05)	0.00	(0.24)
1999	0.40	0.28	0.27	0.38	0.70	0.26	0.30	0.40	0.53	0.22	0.28	0.32	(0.58)
2000	0.37	0.31	0.37	0.33	0.50	0.26	0.28	0.22	0.34	0.15	0.29	0.20	(0.01)
2001	0.20	0.18	0.24	0.13	0.34	0.04	0.19	0.21	0.27	0.01	0.09	0.57	0.39
2002	0.11	0.20	0.29	0.36	0.53	0.15	0.36	0.25	0.50	0.11	0.38	0.66	0.30
2003	0.24	0.25	0.24	0.31	0.49	0.24	0.33	0.27	0.40	0.20	0.33	0.42	0.08
2004	0.32	0.27	0.21	0.29	0.44	0.18	0.23	0.19	0.28	0.16	0.21	0.46	0.28

According to the table 2.1, each value in the table2.1 is the growth rate of container throughput per year, which is got by the calculation that the difference between the

[6] Appendix table1-table10

close year's values of container throughput per year divides the first year's value of container throughput per year. It could represent the growth speed of container throughput per year in some ports. Meanwhile, the series of same values in the vertical line could express the fluctuation of growth rate of port container throughput. For example, according to the table, the large fluctuation of the curve could express the large fluctuation of growth rate of port container throughput. The bracketed values represent the growth rate value is negative, that is to say, the container throughput in the year is going down than the value in the last year, so the fuscous and bracketed values represent there used to be negative growth trend in the history of the container throughput in some ports.

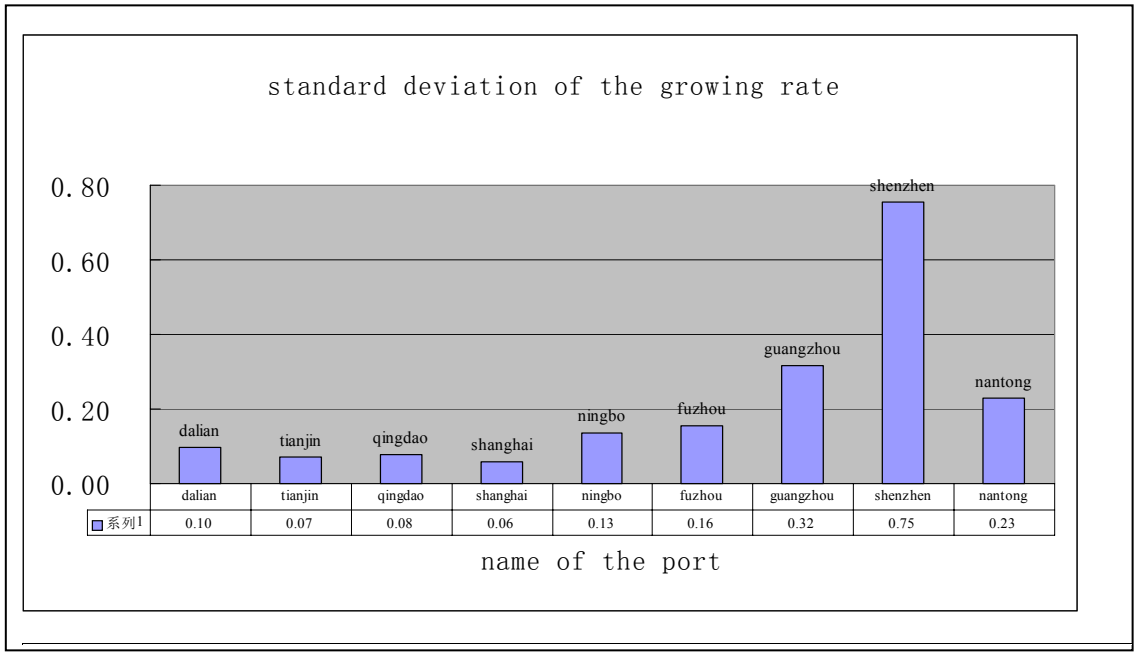
Therefore, regarding to the criteria of the growth rate of container throughput per year, ports could be divided into respective groups regarding the fluctuation of growth rate of port container throughput. All of ports could be divided into the two classifications: first is the ports in the fluctuation of growth degree of port container throughput with negative increasing trend, which are exclusive out of the research scope in this thesis, they are Shantou, Naning, Xiamen and Wuhan; second is the most of ports that do not have negative growth trend in the history of the container throughput. Those ports need to be further divided regarding the next criteria.

In the summary, the scope of the ports could be reduced:
First, port need to be the international port, which ensures that the same group of ports is affected by the parallel motives and aims. This type of ports is all expressing the relationship between China and other countries. Otherwise, the local port could be highly affected by the area economic development. And, different areas have their own economic features.

Second criteria is the port without the negative growth trend, that is to say, there is no negative value in the vertical line in the table of growth rate of container throughput and there used to be not negative growth trend in the history of the container throughput in some ports.

2.3 The Criteria of Standard Deviation of Growth Rate of Container Throughput per Year

Table 2.2 –The standard deviation of growth rate of port container throughput per year.



According to the Table 2.2, the each value in the table is the standard deviation of growth rate of container throughput, which is got by the calculation in the software of excel with growth rate of container throughput per year. It could represent the distribution degree of growth rate of container throughput in some ports. And, the big value of standard deviation of growth rate of container throughput express the separate distribution of growth rate of container throughput in some ports. In the opposite, the small value of standard deviation of growth rate of container throughput

could express the close distribution of growth rate of container throughput in some ports.

Therefore, according to the criteria of standard deviation, ports could be divided into respective classifications regarding standard deviation of growth rate of container throughput. Qingdao, Dalian and Ningbo could represent the close distribution of growth rate of container throughput in some ports; Fuzhou, Guangzhou and Nantong could represent the largest the fluctuation of growth degree of port container throughput without negative increasing trend.

In the end, the classifications of the port are finished; the followings are the classifications in the scope of this thesis:
First classification are Qingdao, Dalian and Ningbo chosen to represent the international port, whose standard deviation of growth rate of container throughput is in the restriction between 0.08 and 0.15 without negative growth trend.

Second classification in the scope of this thesis are Fuzhou, Guangzhou and Nantong are chosen to represent the international port, whose standard deviation of growth rate of container throughput is in the restriction between 0.15 and 0.32 without negative growth trend.

3. Forecasting Method Chosen

The port container throughput forecasting methods are chosen for the evaluation. In fact, the time series forecasting, regression forecasting and grey system are confirmed, which are universal in the container throughput forecasting. In detail, the third exponential smoothing in the time series forecasting, simple line regression in the regression forecasting and GM(1,1) in the grey system are chosen, which are classic in the usage of container throughput forecasting and respective forecasting method series.

3.1 Time Series Forecasting

Forecasting by time series regression is to build time series regression model by the historic data resources, and forecast the future by the usage of the model. There are two assumptions in the time series regression: First, the parameters which decide the developing trend in the past several years will affect the developing trend in the next several years. Second, the process of development mostly is step by step, and is hardly sudden changing.

Moving average forecasting belonging to time series forecasting calculates the average value of the groups of historic data resources, and forecast the future by the average value. Moving average forecasting could be divided into sample average method, sample moving average method and second moving average method. Moving average method is easy to understand and avoid the seasonal varieties in the data resources.

Exponential smoothing method develops from the time series and becomes one of

time series forecasting method. The character of exponential smoothing is to get the relevant predicted value according to the actual value and historic prediction. In the process of forecasting the container port throughput, exponential smoothing assume that container port throughput develop regarding the level trend, and focus on recent container port throughput that affect the item in the next period in the largest degree. On the assumption that long-term throughput hardly influent the item in the next period, the percentage of consideration on the long-term throughput is relatively small. The common exponential smoothing is divided into the first exponential smoothing, second exponential smoothing and third exponential smoothing.

The time series are constantly used in the forecasting of container throughput, which do have the features of the simplifying of the forecasting model and the good reaction to the fluctuation of the original data

3.2 Regression Forecasting

Regression forecasting is based on numeral statistics relationship between two items. Regression models describe the relationship through measurable datasheet. Regarding the type of function between independent variables and variables, regression model could be classified into liner regression. Meanwhile, regarding the amount of independent variables, liner regression could be classified into simple liner regression and multiple regressions.

The followings are basic means of regression:
First, analyze the groups of the data, and find out the certain function relationship among the groups of variables.

Second, analyze the degree of the relationship between independent variables and

variables. And, calculate the concrete value of the coefficients.

Third, regarding the relevant original data, certain function and parameters, forecast the value of the object. And, make the process of quality assessment and errors of the result.

Regression is based on the principle between cause and effect, which express the high reliability in the container throughput forecasting. Therefore, regression is the reasonable forecasting methods in the prediction of the port throughput.

3.3 Grey System Forecasting

Grey theory focuses on model uncertain information insufficiency in analyzing systems on prediction and decision-making, which covers by The GM (1,N) model, the GM (1,1) model and the grey Verhulst model include data processing, modeling and prediction. The grey theory mainly works on systems with poor and incomplete information. The GM (1, N) model, the GM (1, 1) model and the grey Verhulst model are the main models in grey theory. The GM (1, N) model fit for application to systems, analysis, data processing, prediction. The GM (1, 1) model is suitable for up-to-date data to forecast future values. The grey Verhulst model is a extra model in the grey system.

The GM(1,1) is frequently used grey forecasting model, which is a time series forecasting model. The GM(1,1) model is relatively applicable to describe the various process. The popular grey model, GM(1,1) is efficient for port throughput forecasting.

4. Forecasting Model Application

Because the article does no focus on the forecasting results of some ports, the calculation of the forecasting models is just simply illustrated.

As the concrete forecasting process of other ports is similar to Qingdao port, the other calculation table calculation procedure will be ignored and be given in the Appendix part.

4.1 The Operation Process in Forecasting Models

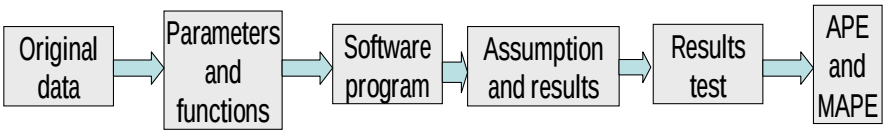


Figure 4.1 The Operation Process in Forecasting Models

A，The original data are chosen and collected. The port container throughput of each port per year is chosen. The fifteen data of each port from 1990 to 2004 are collected. As accuracy and the sameness of other data in each port such as GDP in the certain areas is difficult, other related data are out of the picked range.

B，The functions and parameters of the certain kind of forecasting method need to be clarified and explained according to the concrete research object and original data.

C，The program language are built through the function and software of excel, which could simplify the choice of the guideline for forecasting models optimization and have the forecasting result more clear.

D，The original data input in the program and forecasting result could be got. Especially, on the assumption that the latest original data of the container throughput in the last three years from the year of 2002 to the year of 2004 are all unknown, the rest of original data input in the program, and the forecasting result are got as the container throughput of the last three years.

E，The test need to be done, which focus on the forecasting value and make the judgments whether the forecasting result are accepted.

F，Then, the APE (absolute percentage error) could be calculated that the difference between the forecasting result and collected practical value divide collected practical value. The MAPE (mean absolute percentage error) is the average of APE in three years.

4.2 The Operation Process in Third Exponential Smoothing Model

The followings are the functions of third exponential smoothing model:

$$Y(t+1)=\alpha X(t)+(1-\alpha)Y(t)$$

$$S_t^{(1)}=\alpha X_t+(1-\alpha)S^{(1)}_{t-1}$$
$$S_t^{(2)}=\alpha S^{(1)}_t+(1-\alpha)S^{(2)}_{t-1}$$
$$S_t^{(3)}=\alpha S^{(2)}_t+(1-\alpha)S^{(3)}_{t-1}$$

$$a_t=3S^{(1)}_t-3S^{(2)}_t+3S^{(3)}_t$$
$$b_t=\frac{\alpha}{2(1-\alpha)^2}[(6-5\alpha)S^{(1)}_t-2(5-4\alpha)S^{(2)}_t+(4-3\alpha)S^{(3)}_t]$$
$$c_t=\frac{\alpha^2}{2(1-\alpha)^2}[S^{(1)}_t-2S^{(2)}_t+S^{(3)}_t]$$

X(t) means origin data in the t point.

Y(t) means forecasting value in the t point.

α is smoothing parameters.

$S_t^{(1)}$ means smoothing parameters in the t point under the first exponential

smoothing model.

$S_t^{(2)}$ means smoothing parameters in the t point under the second exponential smoothing model.

$S_t^{(3)}$ means smoothing parameters in the t point under the third exponential smoothing model.

$a_t b_t c_t$ are all smoothing parameters under the third exponential smoothing model.

It is built and calculated by excel that forecasting process of container throughput of Qingdao port is under third exponential smoothing model.

First, put the original data into the data column, according to the consequence of the year.

Second, according to the function, put the basic equation in the basic cell.

C6=D6=E6=F6

D7=$D$4*C7+D6*(1-$D$4)

E7=$D$4*D7+E6*(1-$D$4)

F7=$D$4*E7+F6*(1-$D$4)

G6=3*(D6-E6)+F6

H6=($D$4/2*(1-$D$4)^2)*((6-5*$D$4)*D6-(10-8*$D$4)*E6+(4-3*$D$4)*F6)

I6==$D$4^2/(1-$D$4)^2*(D6-2*E6+F6)

J18=H17+G17+I17

J19=G17+H17*2+I17*4

J20=G17+H17*3+I17*9

K18==ABS ((J18-C18)/C18)

H20==AVERAGE (K18:K20)

I20=STDEV (K18:K20)

Third, copy the basic equation into other cells.

Table 4.1 –container throughput forecasting of Qingdao port in third exponential smoothing and 12 original data

A	B	C	D	E	F	G	H	I	J	K	1
container throughput forecasting of Qingdao port in third exponential smoothing and 12 original data											2
											3
		X=	0.65								4
year	number	data	S_1	S_2	S_3	a_t	b_t	c_t	forecast	APE	5
1990	1	28.58	28.584	28.584	28.584	28.584	0.000	0.000			6
1991	2	33.77	31.955	30.775	30.008	33.548	0.067	1.424			7
1992	3	39.35	36.762	34.667	33.036	39.322	0.096	1.604			8
1993	4	48.19	44.191	40.857	38.120	48.120	0.142	2.056			9
1994	5	63.09	56.476	51.010	46.498	62.898	0.230	3.295			10
1995	6	70.2	65.397	60.361	55.509	70.616	0.155	0.633			11
1996	7	82.3	76.384	70.776	65.433	82.256	0.178	0.912			12
1997	8	93.6	87.574	81.695	76.003	93.641	0.179	0.647			13
1998	9	101.8	96.821	91.527	86.094	101.976	0.136	-0.480			14
1999	10	130.2	118.517	109.071	101.029	129.369	0.378	4.845			15
2000	11	170.8	152.501	137.300	124.605	170.207	0.628	8.641			16
2001	12	201.1	184.090	167.714	152.626	201.755	0.562	4.444			17
2002	13	240.8					MAPE		206.761	0.141	18
2003	14	301.5					=		220.654	0.268	19
2004	15	381.6					0.257		243.435	0.362	20

Table 4.2 –container throughput forecasting of Qingdao port in third exponential smoothing and 6 original data

A	B	C	D	E	F	G	H	I	J	K	1
container throughput forecasting of Qingdao port in third exponential smoothing and 6 original data											2
											3
		X=	0.5								4
year	number	data	S_1	S_2	S_3	a_t	b_t	c_t	forecast	APE	5
1998	1	81	81	81	81	81	0	0			6
1999	2	103.3	92.150	86.575	83.788	100.513	0.784	2.787	81.000		7
2000	3	121.3	106.725	96.650	90.219	120.444	1.199	3.644	104.084		8
2001	4	154.2	130.463	113.556	101.888	152.606	1.875	5.237	125.287		9
2002	5	212	171.231	142.394	122.141	208.653	3.144	8.584	159.719		10
2003	6	263.9	217.566	179.980	151.060	263.818	3.703	8.666	220.381		11
2004	7	341						MAPE	276.188	0.190	12
2005	8	423.9						=	305.890	0.278	13
2006	9	514						0.261	352.925	0.313	14

Fourth, test the percentage of the accuracy of the model.

Fifth, according to the forecasting result, the MAPE is calculated to get the value of 0.257 in the 12 original data and 0.261 in the 6 original data.

4.3 The Operation Process in Simple Line Regression Model

It is described that forecasting process of container throughput of Qingdao port is under regression forecasting, simple liner regression model.

The followings are the functions of regression forecasting, simple liner regression model:

$$b = \frac{n\sum x_i y_i - \sum x_i \sum y_i}{n\sum x_i^2 - (\sum x_i)^2}$$

$$a = \frac{\sum y_i \sum x_i^2 - \sum x_i \sum x_i y_i}{n\sum x_i^2 - (\sum x_i)^2}$$

$$S = \sum_{n} (yi - (a + bxi))2$$

X(t) means origin data in the t point

Y(t) means forecasting result in the t point.

Table 4.3–container throughput forecasting of Qingdao port in third exponential smoothing and 6 original data

A	B	C	D	E	1
container throughput forecasting of Qingdao port in third exponential smoothing and 6 original data					2 3
year	number	data	forecast	APE	4
1998	1	81	79.341		5
1999	2	103.3	100.580		6
2000	3	121.3	127.505		7
2001	4	154.2	161.638		8
2002	5	212	204.907		9
2003	6	263.9	259.760		10
2004	7	341	329.296	0.036	11
2005	8	423.9	417.447	0.015	12
2006	9	514	529.195	0.029	13
				MAPE	14
				0.027	15

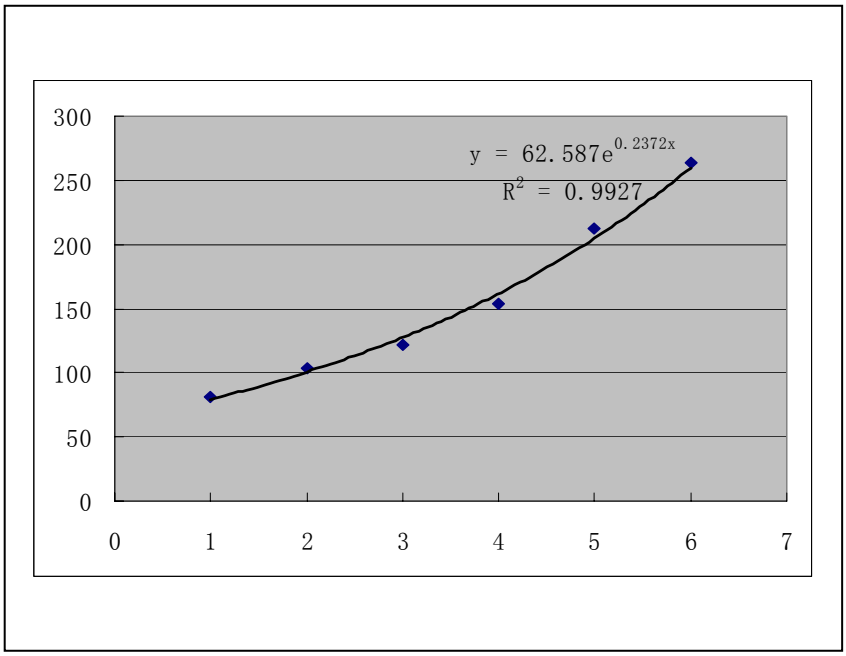


Figure 4.2–container throughput forecasting of Qingdao port in third exponential

smoothing and 6 original data

Table 4.4–container throughput forecasting of Qingdao port in third exponential smoothing and 12 original data

A	B	C	D	E	1
container throughput forecasting of Qingdao port					2
in third exponential smoothing and 12 original data					3
year	number	data	forecast	APE	4
1990	1	28.58	28.687		5
1991	2	33.77	34.108		6
1992	3	39.35	40.554		7
1993	4	48.19	48.218		8
1994	5	63.09	57.330		9
1995	6	70.2	68.165		10
1996	7	82.3	81.047		11
1997	8	93.6	96.364		12
1998	9	101.8	114.575		13
1999	10	130.2	136.228		14
2000	11	170.8	161.973		15
2001	12	201.1	192.584		16
2002	13	240.8	228.979	0.049	17
2003	14	301.5	272.253	0.097	18
2004	15	381.6	323.705	0.152	19
			MAPE		20
			0.099		21

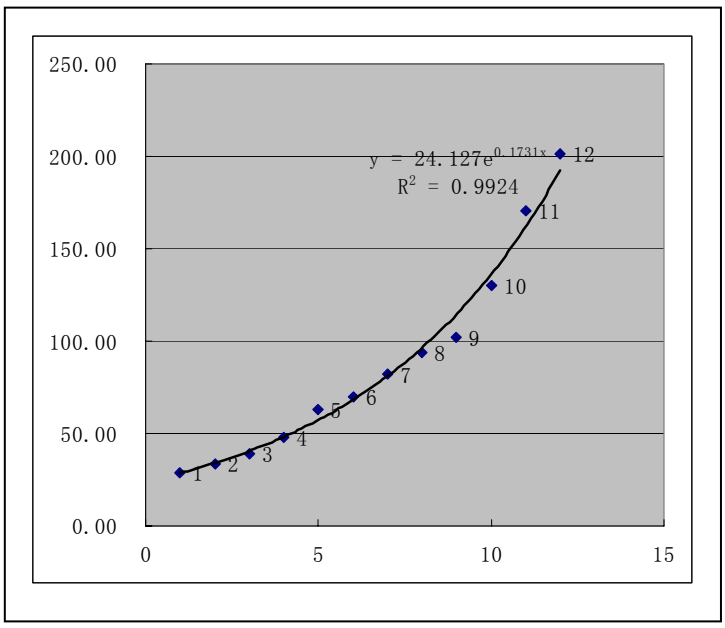


Figure 4.3–container throughput forecasting of Qingdao port in third exponential smoothing and 12 original data

a and b are parameters under regression forecasting, simple liner regression model..

It is built and calculated by excel that forecasting process of container throughput of Qingdao port is under regression forecasting, simple liner regression model.

First, put the original data into the data column, according to the consequence of the year.

Second, test the percentage of the accuracy of the mode by the equation and the value of R.

Third, according to the forecasting result, the MAPE is calculated to get the value of 0.099 in the 12 original data 0.027 in the 6 original data.

4.4 The Operation Process in GM(1,1) Model

It is described that forecasting process of container throughput of Qingdao port is under grey system, GM (1, 1) model.

The followings are the functions of third grey system, GM(1, 1) model:

$$Y_t = \sum_{i=0}^{t} X_i \qquad (t = 0,\ 1,\ 2,\ \cdots,\ n) \qquad (1)$$

$$Z_t = 1/2(Y_t + Y_{t-1}) \qquad (t = 1,2,3,\cdots,n) \qquad (2)$$

$$\frac{dY_t}{dt} + \alpha Yt = \mu \qquad (3)$$

$$Y_t = (X_0 - \frac{\mu}{\alpha})e^{-\alpha t} + \frac{\mu}{\alpha} \qquad (t = 0,1,2,\cdots,n) \qquad (4)$$

$$\alpha = [(\sum_{i=1}^{n} X_i)(\sum_{i=1}^{n} Z_i) - n(\sum_{i=1}^{n} Z_i X_i)] / D \qquad (5)$$

$$\mu = [(\sum_{i=1}^{n} Z_i^2)(\sum_{i=1}^{n} X_i) - (\sum_{i=1}^{n} Z_i)(\sum_{i=1}^{n} Z_i X_i)] / D \qquad (6)$$

$$D = n(\sum_{i=1}^{n} Z_i^2) - (\sum_{i=1}^{n} Z_i)^2 \qquad (7)$$

$$\hat{X}_t = Y_t - Y_{t-1} \qquad (t = 1,\ 2,\ 3,\ \cdots,\ n) \qquad (8)$$

$$\delta(t) = X_t - \hat{X}_t$$

$$S_1 = \sqrt{\frac{\sum_{i=1}^{n} (\delta_i - \bar{\delta})^2}{n}}$$

$$S_2 = \sqrt{\frac{\sum_{i=1}^{n} (Xt - \bar{X})^2}{n}}$$

$$C = S_1 / S_2$$

X(t) means origin data in the t point.

Y(t) means forecasting result in the t point.

α μ and D are all grey system parameters under GM(1,1) model.

It is built and calculated by excel that forecasting process of container throughput of Qingdao port is under grey system, GM(1, 1) model.

First, put the original data into the data column, according to the consequence of the

year.

Second, according to the function, put the basic equation in the basic cell.

D5=C5

D6=D5+C6

E6=(D5+D6)/2

F6=C6*E6

G6=POWER(E6,2)

H6=$F$23*EXP(-$D$22*B6)+$F$22

I6=H6-H5

J6=C6-I6

K6=ROUND(J6/C6*100,2)

C17=SUM(C6:C16)

D19=ROUND(STDEVP(C6:C16),2)

D21=ROUND(B16*G17-POWER(E17,2),4)

D22=ROUND((E17*C17-B16*F17)/D21,4)

D23=ROUND((C17*G17-E17*F17)/D21,4)

F22=D23/D22

F23=C5- F22

J23=ROUND(J21/D19,4)

K18=ABS(I18-C18)/C18

K22=AVERAGE(K18:K20)

Third, copy the basic equation into other cells.

Table 4.5–container throughput forecasting of Qingdao port in grey system GM(1,1)and 12 original data

A	B	C	D	E	F	G	H	I	J	K	1
container throughput forecasting of Qingdao port in grey system GM(1,1)and 12 original data											2
											3
year	number	x	y	z	xz	zz	yt	forecast			4
1990	0	28.58	28.5839				28.5839	28.584			5
1991	1	33.77	62.354	45.46895	1535.491	2067.4254	60.71255	32.129	1.641		6
1992	2	39.35	101.7043	82.02915	3227.872	6728.7814	99.13141	38.419	0.931		7
1993	3	48.19	149.8949	125.7996	6062.358	15825.539	145.072	45.941	2.250		8
1994	4	63.09	212.9866	181.4408	11447.41	32920.746	200.0068	54.935	8.157		9
1995	5	70.2	283.1866	248.0866	17415.68	61546.961	265.6969	65.690	4.510		10
1996	6	82.3	365.4866	324.3366	26692.9	105194.23	344.2479	78.551	3.749		11
1997	7	93.6	459.0866	412.2866	38590.03	169980.24	438.1778	93.930	-0.330		12
1998	8	101.8	560.8866	509.9866	51916.64	260086.33	550.4974	112.320	-10.520		13
1999	9	130.2	691.0866	625.9866	81503.46	391859.22	684.8071	134.310	-4.110		14
2000	10	170.8	861.8866	776.4866	132623.9	602931.44	845.4121	160.605	10.195		15
2001	11	201.1	1062.9866	962.4366	193546	926284.21	1037.461	192.049	9.051		16
	12	1034.403	4811.546	4294.345	564561.7	2575425.1	1267.109	229.648		APE	17
2002	13	240.8	S_2=				1541.718	274.609		0.140	18
2003	14	301.5	51.44				1870.09	328.372		0.089	19
2004	15	381.6					2262.752	392.662	S_1=	0.029	20
		D=	9888280.4						2.620	MAPE	21
		X=	-0.1788	W/X=	-135.521				C=	0.086	22
		W=	24.2311	X_1-W/X=	164.1046				0.0509		23

Table 4.6–container throughput forecasting of Qingdao port in grey system GM(1,1)and 6 original data

A	B	C	D	E	F	G	H	I	J	K	1
container throughput forecasting of Qingdao port in grey system GM(1,1)and 6 original data											2
											3
year	number	x	y	z	xz	zz	yt	forecast			4
1998	0	81	81				81	81			5
1999	1	103.3	184.3	132.65	13702.75	17596.023	177.6129	96.61288	6.687		6
2000	2	121.3	305.6	244.95	29712.44	60000.503	301.5175	123.9046	-2.605		7
2001	3	154.2	459.8	382.7	59012.34	146459.29	460.4234	158.9059	-4.706		8
2002	4	212	671.8	565.8	119949.6	320129.64	664.2179	203.7945	8.206		9
2003	5	263.9	935.7	803.75	212109.6	646014.06	925.5814	261.3635	2.537		10
	6	854.7	2557.2	2129.85	434486.7	1190199.5	1260.776	335.1949		APE	11
2004	7	341	S_2=				1690.659	429.8826		0.261	12
2005	8	423.9	59.41				2241.977	551.3182		0.301	13
2006	9	514					2949.035	707.0576	S_1=	0.376	14
		D=	1414736.6						5.039	MAPE	15
		X=	-0.2488	W/X=	-261.01				C=	0.312	16
		W=	64.9393	X_1-W/X=	342.01				0.085		17

Fourth, test the percentage of the accuracy of the mode by the equation and the value of c. If the value of c is more than 0.35, the grey system needs to be modified. If the value of c is less than 0.35, the grey system is successful.

Fifth, according to the forecasting result, the MAPE is calculated to get the value of 0.086 in the 12 original data 0.0312 in the 6 original data

5. Forecasting Results Analysis

5.1 Groups of Forecasting Result MAPE

The analysis is around the MAPE of the forecasting results. Therefore, All the MAPE values are categorized into six groups according to the type of two parameters: the forecasting method and the standard deviation of the port container throughput growth rate.

Table 5.1–Groups of forecasting result MAPE

Groups of forecasting result MAPE				
METHOD / PORT	Third exponential smoothing	simple liner Regression	GM(1,1)	STDEV
Qingdao Dalian Ningbo	**A**	**B**	**C**	**0.08-0.15**
Fuzhou Guangzhou Nantong	**D**	**E**	**F**	**0.15-0.32**

A: The forecasting method is third exponential smoothing, and the standard deviation of the port container throughput growth rate is in the restriction between 0.08 and 0.15.

B: The forecasting method is simple liner regression, and the standard deviation of the port container throughput growth rate is in the restriction between 0.08 and 0.15.

C: The forecasting method is GM(1,1), and the standard deviation of the port

container throughput growth rate is in the restriction between 0.08 and 0.15.

D: The forecasting method is third exponential smoothing, and the standard deviation of the port container throughput growth rate is in the restriction between 0.15 and 0.32.

E: The forecasting method is simple liner regression, and the standard deviation of the port container throughput growth rate is n the restriction between 0.15 and 0.32.

F: The forecasting method is GM(1,1), and the standard deviation of the port container throughput growth rate is n the restriction between 0.15 and 0.32.

5.2 Circumstance One: Forecasting Result MAPE in the Adequate Data

Table 5.2–Forecasting Result MAPE in the Adequate Data

Forecasting result MAPE in the adequate data			
METHOD / PORT	Third exponential smoothing	simple liner Regression	GM(1,1)
Qingdao	25.72%	9.93%	8.62%
Dalian	17.33%	5.87%	18.25%
Ningbo	45.17%	12.42%	7.57%
Fuzhou	18.77%	52.77%	52.79%
Guangzhou	27.85%	15.39%	43.88%
Nantong	12.27%	7.85%	45.37%

All the values are calculated in the application of models part. The first line value is got from the case of Qingdao in the Chapter4, and other values could be checked in the appendix.

According to the table, in the circumstance of adequate data:
in the first classification, the forecasting result of third exponential smoothing is worst accurate in all of Qingdao, Dalian and Ningbo port, which could be judged from the highest mean absolute percentage in the group A and indicated by the fuscous color. In the opposite, simple liner regression and GM(1,1) supply the most accurate forecasting result respectively in the group B and group C, which is indicated by the tint color.

Therefore, in the combined forecasting, in the first classification ports, third exponential smoothing is the last chosen forecasting method in the series forecasting methods. Even, third exponential smoothing is considered in the combined

forecasting; it would be given the lowest weighted in the calculation of the forecasting result under the reasonable distribution of weighted mean.

In the second classification, the forecasting result of GM(1,1) is worst accurate in all of Qingdao, Dalian and Ningbo port, which could be judged from the highest mean absolute percentage in the group C and indicated by the fuscous color. In the opposite, simple liner regression and third exponential smoothing supply the most accurate forecasting result respectively in the group D and group E, which is indicated by the tint color.

Therefore, in second classification ports, GM (1, 1) is the last chosen forecasting method in the series forecasting methods. Even, GM (1, 1) is considered in the combined forecasting, it would be given the lowest weighted in the calculation of the forecasting result under the reasonable distribution of weighted mean.

5.3 Circumstance Two: Forecasting Result MAPE in the Limited Data

Table 5.3–Forecasting Result MAPE in the Limited Data

Forecasting result MAPE in the limited data			
METHO / D PORT	Third exponential smoothing	simple liner Regression	GM(1,1)
Qingdao	26.06%	2.66%	31.23%
Dalian	15.63%	9.47%	56.72%
Ningbo	44.72%	4.13%	38.85%
Fuzhou	18.92%	7.48%	20.71%
Guangzhou	27.67%	4.88%	28.91%
Nantong	15.23%	8.50%	9.80%

According to the table5.3, in the circumstance of limited data:

In the first classification, the forecasting result of simple liner regression is best accurate in all of Qingdao, Dalian and Ningbo port, which could be judged from the highest mean absolute percentage and indicated by the tint color. In the opposite, third exponential smoothing and GM(1,1) supply the less accurate forecasting result respectively in the group A and group C.

In the second classification, the forecasting result of simple liner regression is best accurate in all of Qingdao, Dalian and Ningbo port, which could be judged from the highest mean absolute percentage in the group E and indicated by the tint color. In the opposite, third exponential smoothing and GM(1,1) supply the less accurate forecasting result respectively in the group D and group F.

Therefore, in the combined forecasting, in the both of classification ports, simple liner regression is the first chosen forecasting method in the series forecasting methods. If simple liner regression is considered in the combined forecasting, it would be given higher weighted in the calculation of the forecasting result under the reasonable distribution of weighted mean.

It is obvious that simple liner regression provides the most accurate forecasting result in the limited data situation, both in the two classifications, which is caused by the close relationship between the local or domestic economic development and the port-related trade in recent years. In this background relationship, other influenced parameters and criteria hardly affect the value in the future in the large degree.

5.4 Changing Percentage of Forecasting Result MAPE Between the Adequate Data and Limited Data

Table 5.4–Changing percentage of forecasting result MAPE between the adequate data and limited data

Changing percentage of forecasting result MAPE between the adequate data and limited data			
METHOD / PORT	Third exponential smoothing	simple liner Regression	GM(1,1)
Qingdao	-1.31%	273.60%	-72.41%
Dalian	10.90%	-37.98%	-67.82%
Ningbo	0.99%	200.30%	-80.52%
Fuzhou	-0.81%	605.66%	154.88%
Guangzhou	0.64%	215.44%	51.76%
Nantong	-19.48%	-7.69%	363.08%

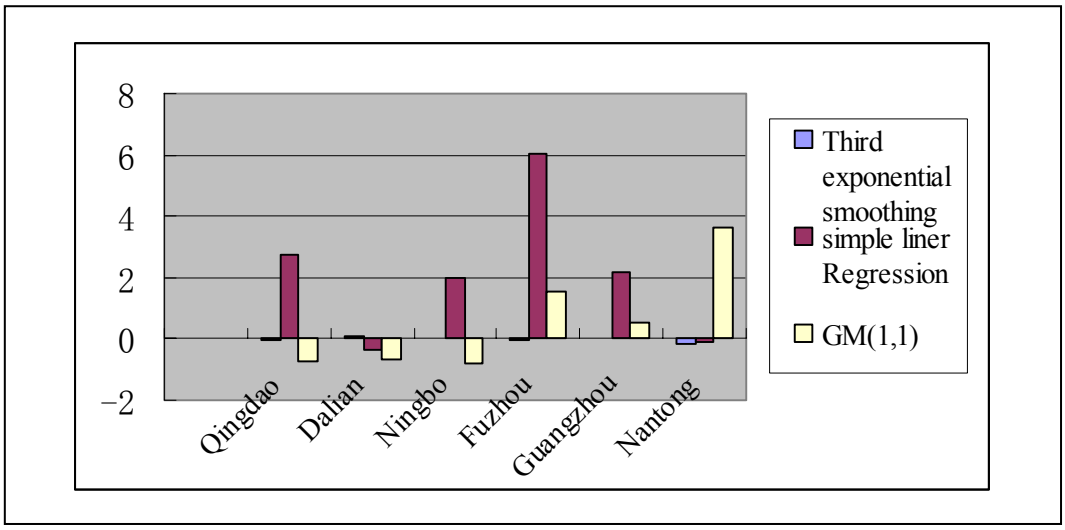


Figure 5.1–Changing percentage of forecasting result MAPE between the adequate data and limited data

According to the table5.4, the changing percentages of MAPE are calculated that the difference between MAPE in the adequate (12) data circumstance and in the limited data circumstance divide the MAPE in the limited (6) data circumstance. On the assumption on that the forecasting model is ensured in the first place, regarding the degree of the changing percentages of MAPE, optimizing guideline could be judged that whether it could improve the forecasting result. Then, if the guideline is accepted, the correct optimizing direction could be judged from the positive or negative value of the changing percentages of MAPE. This thesis choose the data resource as the optimizing guideline, if this guideline is accepted, the correct optimizing direction is supposed to be chosen between the adequate data and limited data.

According to the table5.4, in all the classifications:
First, third exponential smoothing expresses the least changing percentage of MAPE, which could be judged from the smallest value of changing percentage of forecasting result MAPE in the group A, D and could be indicated by the tint color. Meanwhile, the changing percentage degree of forecasting result MAPE could be investigated in the pillar table.

Therefore, in all the classifications, third exponential smoothing is barely influenced by the numbers of the original data among the series forecasting methods. If third exponential smoothing is considered in the optimizing forecasting or combined forecasting, the numbers of original data would be almost ignored in the calculation of the forecasting result in the optimizing process. Less energy could be put in the collection of the original data.

Second, GM(1,1) expresses the relatively larger changing percentage of forecasting result MAPE between adequate data and limited data of in group C and F, which

could be judged from the value changing percentage of forecasting result MAPE. The degree of changing percentage of forecasting result MAPE could be investigated in the pillar table.

Therefore, GM (1, 1) is much influenced by the numbers of the original data among the series forecasting methods. If GM(1,1) is considered in the optimizing forecasting, the numbers of original data would be highlighted. And, in the group C, the changing percentage is all negative, so the optimizing direction is from the a limited data to the adequate data, that is to say, on the assumption that GM(1,1) is adapted in the ports in the first classification of ports, the increasing of the amount of the parameters along time consequence in the permitted scope could help improve the forecasting results. In the opposite, in the group F the changing percentage is all positive, so the optimizing direction is from the adequate data to the limited data, that is to say, on the assumption that GM(1,1) is adapted in the ports in the second classification of ports, the reduction of the amount of the parameters along time consequence in the permitted scope could help improve the forecasting results.

Third, simple liner regression expresses the largest changing percentage of forecasting result MAPE between adequate data and limited data of in all of Qingdao, Dalian and Ningbo port, which could be judged from the biggest value of changing percentage of forecasting result MAPE in the group A and indicated by the fuscous color. The degree of changing percentage of forecasting result MAPE between adequate data and limited data in simple liner regression could be investigated in the line curve, which discovers the largest difference of changing percentage of forecasting result MAPE compared to other forecasting method.

Therefore, simple liner regression is much influenced by the numbers of the original

data among the series forecasting methods. If simple liner regression is considered in the optimizing forecasting or combined forecasting, the numbers of original data would be almost highlighted in the optimizing process. And, the changing percentage is positive in most of time, so the optimizing direction is from the adequate data to the limited data, that is to say, the reduction of the amount of the parameters along time consequence in the permitted scope could help improve the forecasting results in most of both categories of ports.

6. Conclusions

6.1 Forecasting Model Choice

6.1.1 Forecasting Models Choice in the First Classification

On the assumption on that the port is restricted in the named circumstance, the forecasting model could be chosen among the groups.

When the ports fulfill the following criteria: First, the port is mainly international port in China. Second, there is no negative growth trend of container throughput in the last 15 years. Third, the standard deviation of the port container throughput growth rate is in the restriction between 0.08 and 0.15..

In the circumstance of adequate data and in the combined forecasting:
Third exponential smoothing is the last chosen forecasting method in the series forecasting methods.

In the circumstance of limited data and in the combined forecasting:
Simple liner regression is the first chosen forecasting method in the series forecasting methods.

6.1.2 Forecasting Models Choice in the Second Classification

When the ports fulfill the following criteria: First, the port is mainly international port in China. Second, there is no negative growth trend of container throughput in the last 15 years. Third, the standard deviation of the port container throughput growth rate is in the restriction between 0.15 and 0.32.

In the circumstance of adequate data and in the combined forecasting:
GM (1, 1) is the last chosen forecasting method in the series forecasting methods.

In the circumstance of limited data and in the combined forecasting:
Simple liner regression is the first chosen forecasting method in the series forecasting methods.

6.2 Forecasting Model Optimization

6.2.1 Optimization of the Third Exponential Smoothing Model

The third exponential smoothing model is ensured, the changing percentage of MAPE is hardly varying in both categories of ports. Therefore, the data resource as the optimizing guideline is not accepted.

6.2.2 Optimization of the Simple Line Regression Model

The simple line regression model is confirmed, the changing percentage of MAPE is changing obviously in most of both categories of ports. Therefore, the data resource as the optimizing guideline is accepted. And, the changing percentage is all positive, so the optimizing direction is from the adequate data to the limited data in most of both categories of ports.

6.2.3 Optimization of the GM (1, 1) Model

The GM (1, 1) model is confirmed, the changing percentage of MAPE is changing obviously in all of ports. Therefore, the data resource as the optimizing guideline is accepted.

And, in the group C, the changing percentage is all negative, so the optimizing direction is from the limited data to the adequate data.

In the opposite, in the group F the changing percentage is all positive, so the optimizing direction is from the adequate data to the limited data.

6.3 Validation of the Principal Assumption

This theory and principal assumption has been confirmed because thesis has got the conclusion in the classifications of forecasting researching. In detail, according to the SOP for the choice of forecasting method in the combined forecasting circumstance and the guideline and direction in the optimizing forecasting procedures, the concrete choices of forecasting method for the classifications of port have been made, and the optimizing guideline and direction has been ensured for the concrete forecasting method.

However, the theory and principal assumption need to be further perfected by the large amount of practical validation.

7. Recommendation

Because of the limitation of time, energy and knowledge background, less forecasting methods, research object and parameters of direction are considered. In fact, much more research jobs could be done along this theory assumption.

On the one hand, more types of port could be divided and tested in the forecasting process. And, there are hundreds of forecasting methods in the port container throughput forecasting, and more classification ports could be put in the scope of forecasting research;

On the other hand, only three simple and classic forecasting models in three kinds of forecasting method series are in the range of this passage, more models and more kinds of forecasting method series could put in this theory assumption.

And, the conclusion of this thesis of forecasting models in those two classification ports is not absolute. Maybe, some port container throughput does not work according to the conclusion, because all of the forecasting conclusions are got in its own economic and information background and the conclusions. And, the theory assumption only obeys the most of objects principle.

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Appendix:

Table1.container throughput forecasting of Dalian port in 12 original data

A	B	C	D	E	F	G	H	I	J	K	
container throughput forecasting of Dalian port in third exponential smoothing and 12 original data											2
											3
		X=	0.55								4
year	number	data	S1	S2	S3	A	B	C	forecast	APE	5
1990	1	13.13	13.1259	13.1259	13.1259	13.1259	0	0			6
1991	2	17.28	15.41016	14.38224	13.81689	16.90064	0.112051	0.690989	13.1259		7
1992	3	21.75	18.89509	16.86431	15.49297	21.58532	0.188079	0.985093	17.70368		8
1993	4	25.62	22.59148	20.01425	17.97968	25.71136	0.200182	0.810624	22.75849		9
1994	5	30.50	26.9415	23.82424	21.19419	30.54596	0.219992	0.727802	26.72216		10
1995	6	37.4	32.69367	28.70243	25.32372	37.29746	0.280196	0.915025	31.49376		11
1996	7	42.1	37.86715	33.74303	29.95434	42.32672	0.250593	0.501086	38.49268		12
1997	8	45.3	41.95522	38.25973	34.5223	45.60876	0.179725	-0.06265	43.0784		13
1998	9	52.6	47.80985	43.5123	39.4668	52.35946	0.248373	0.376528	45.72584		14
1999	10	73.6	61.99443	53.67747	47.28267	72.23355	0.66838	2.871374	52.98436		15
2000	11	101.1	83.50249	70.08123	59.82188	100.0857	1.086442	4.723342	75.77331		16
2001	12	121.7	104.5111	89.01767	75.87957	122.3599	1.084746	3.518475	105.8954		17
2002	13	135.2					MAPE		126.9631	0.060924	18
2003	14	167					=		138.6033	0.17004	19
2004	15	221.2					0.173		157.2804	0.288967	20

A	B	C	D	E	
container throughput forecasting of Dalian port in third exponential smoothing and 12 original data					2
					3
year	number	data	forecast	APE	4
1990	1	13.13	13.91395		5
1991	2	17.28	16.79518		6
1992	3	21.75	20.27304		7
1993	4	25.62	24.47108		8
1994	5	30.50	29.53843		9
1995	6	37.4	35.6551		10
1996	7	42.1	43.03837		11
1997	8	45.3	51.95054		12
1998	9	52.6	62.70819		13
1999	10	73.6	75.69349		14
2000	11	101.1	91.36771		15
2001	12	121.7	110.2877		16
2002	13	135.2	133.1255	0.015344	17
2003	14	167	160.6924	0.03777	18
2004	15	221.2	193.9678	0.123111	19
			MAPE		20
			0.059		21

A	B	C	D	E	F	G	H	I	J	K	1
container throughput forecasting of Dalian port in grey system GM(1,1)and 12 original data											2
											3
year	number	x	y	z	xz	zz	yt	forecast			4
1990	0	13.13	13.1259				13.1259	13.1259			5
1991	1	17.28	30.405	21.76545	376.0874	473.7348	26.8246	13.6987	3.580403		6
1992	2	21.75	52.1514	41.2782	897.6522	1703.89	43.67375	16.84916	4.897242		7
1993	3	25.62	77.7672	64.9593	1663.984	4219.711	64.39793	20.72417	4.891629		8
1994	4	30.50	108.2678	93.0175	2837.09	8652.255	89.88829	25.49037	5.010231		9
1995	5	37.4	145.6678	126.9678	4748.596	16120.82	121.241	31.35271	6.04729		10
1996	6	42.1	187.7678	166.7178	7018.819	27794.82	159.8043	38.56329	3.536714		11
1997	7	45.3	233.0678	210.4178	9531.926	44275.65	207.2365	47.43217	-2.13217		12
1998	8	52.6	285.6678	259.3678	13642.75	67271.66	265.5772	58.34074	-5.74074		13
1999	9	73.6	359.2678	322.4678	23733.63	103985.5	337.3353	71.7581	1.841903		14
2000	10	101.1	460.3678	409.8178	41432.58	167950.6	425.5965	88.26121	12.83879		15
2001	11	121.7	582.0678	521.2178	63432.21	271668	534.1563	108.5597	13.14025		16
	12	568.9419	2522.466	2237.995	169315.3	714116.7	667.6829	133.5266		APE	17
2002	13	135.2	S_2=				831.9182	164.2354		0.214759	18
2003	14	167	32.15				1033.925	202.0067	4.3556	0.209621	19
2004	15	221.2					1282.39	248.4647		0.123258	20
		D=	2846661						0.7834	MAPE	21
		X=	-0.207	W/X=	-46.4382					0.183	22
		W=	9.6127	X_1-W/X=	59.56406				C=		23
									0.0244		24

Table2.container throughput forecasting of Dalian port in 6 original data

A	B	C	D	E	F	G	H	I	J	K	1
container throughput forecasting of Qingdao port in third exponential smoothing and 6 original data											2
											3
		X=	0.5								4
year	number	data	S1	S2	S3	A	B	C	forecast	APE	5
1998	1	81	81	81	81	81	0	0			6
1999	2	103.3	92.15	86.575	83.7875	100.5125	0.783984	2.7875	81		7
2000	3	121.3	106.725	96.65	90.21875	120.4438	1.199023	3.64375	104.084		8
2001	4	154.2	130.4625	113.5563	101.8875	152.6063	1.875	5.2375	125.2865		9
2002	5	212	171.2313	142.3938	122.1406	208.6531	3.143652	8.584375	159.7188		10
2003	6	263.9	217.5656	179.9797	151.0602	263.818	3.703247	8.666406	220.3812		11
2004	7	341						MAPE	276.1876	0.190066	12
2005	8	423.9						=	305.8901	0.278391	13
2006	9	514						0.26061	352.9254	0.313375	14

A	B	C	D	E	1
container throughput forecasting of Qingdao port in third exponential smoothing and 6 original data					2 3
year	number	data	forecast	APE	4
1998	1	81	79.341		5
1999	2	103.3	100.580		6
2000	3	121.3	127.505		7
2001	4	154.2	161.638		8
2002	5	212	204.907		9
2003	6	263.9	259.760		10
2004	7	341	329.296	0.036	11
2005	8	423.9	417.447	0.015	12
2006	9	514	529.195	0.029	13
				MAPE	14
				0.027	15

A	B	C	D	E	F	G	H	I	J	K	1
container throughput forecasting of Qingdao port in grey system GM(1,1)and 6 original data											2 3
year	number	x	y	z	xz	zz	yt	forecast			4
1998	0	81	81				81	81			5
1999	1	103.3	184.3	132.65	13702.75	17596.02	177.6129	96.61288	6.687117		6
2000	2	121.3	305.6	244.95	29712.44	60000.5	301.5175	123.9046	-2.60462		7
2001	3	154.2	459.8	382.7	59012.34	146459.3	460.4234	158.9059	-4.70588		8
2002	4	212	671.8	565.8	119949.6	320129.6	664.2179	203.7945	8.205507		9
2003	5	263.9	935.7	803.75	212109.6	646014.1	925.5814	261.3635	2.536516		10
	6	854.7	2557.2	2129.85	434486.7	1190200	1260.776	335.1949		APE	11
2004	7	341	S_2=				1690.659	429.8826		0.260653	12
2005	8	423.9	59.41				2241.977	551.3182		0.300585	13
2006	9	514					2949.035	707.0576	S_1=	0.375598	14
		D=	1414737						5.0385	MAPE	15
		X=	-0.2488	W/X=	-261.01				C=	0.312279	16
		W=	64.9393	X_1-W/X=	342.01				0.0848		17

Table3.container throughput forecasting of Ningbo port in 12 original data

A	B	C	D	E	F	G	H	I	J	K	1
container throughput forecasting of NingBo port in third exponential smoothing and 12 original data											2
											3
		X=	0.55								4
year	number	data	S1	S2	S3	A	B	C	forecast		5
1990	1	2.21	2.2098	2.2098	2.2098	2.2098	0	0			6
1991	2	3.56	2.95428	2.619264	2.435005	3.440053	0.03652	0.225205	2.2098		7
1992	3	5.33	4.258176	3.520666	3.032118	5.24465	0.069544	0.371908	3.701778		8
1993	4	7.88	6.252819	5.02335	4.127296	7.815703	0.105252	0.498064	5.686101		9
1994	5	12.51	9.696139	7.593384	6.033644	12.34191	0.176449	0.811171	8.419019		10
1995	6	16	13.16326	10.65682	8.576389	16.09573	0.181371	0.636397	13.32953		11
1996	7	20.2	17.03347	14.16398	11.64956	20.25804	0.190283	0.530427	16.91349		12
1997	8	25.7	21.80006	18.36382	15.3424	25.65112	0.226506	0.619671	20.97875		13
1998	9	35.3	29.22503	24.33748	20.2897	34.95233	0.354853	1.254451	26.4973		14
1999	10	60.1	46.20626	36.36531	29.13129	58.65414	0.834373	3.894293	36.56163		15
2000	11	90.2	70.40282	55.08594	43.40635	89.35698	1.243658	5.433472	63.3828		16
2001	12	121.3	98.39627	78.90662	62.9315	121.4004	1.436727	5.250091	96.03411	APE	17
2002	13	185.9						MAPE	128.0873	0.310988	18
2003	14	277.2						=	145.2743	0.475923	19
2004	15	400.5						0.451682	172.9614	0.568136	20

A	B	C	D	E	1
container throughput forecasting of NingBo p					2
					3
year	number	data	forecast	APE	4
1990	1	2.21	2.550889		5
1991	2	3.56	3.618436		6
1992	3	5.33	5.132751		7
1993	4	7.88	7.280807		8
1994	5	12.51	10.32783		9
1995	6	16	14.65002		10
1996	7	20.2	20.78106		11
1997	8	25.7	29.47793		12
1998	9	35.3	41.81444		13
1999	10	60.1	59.31379		14
2000	11	90.2	84.13661		15
2001	12	121.3	119.3478		16
2002	13	185.9	169.2948	0.089	17
2003	14	277.2	240.1447	0.134	18
2004	15	400.5	340.6453	0.149	19
				MAPE	20
				0.124	21

A	B	C	D	E	F	G	H	I	J	K	1
container throughput forecasting of NingBo port in grey system GM(1,1)and 12 original data											2
											3
year	number	x	y	z	xz	zz	yt	forecast			4
1990	0	2.21	2.2098				2.2098	2.2098			5
1991	1	3.56	5.7732	3.9915	14.22331	15.93207	4.611288	2.401488	1.162		6
1992	2	5.33	11.0982	8.4357	44.9201	71.16103	8.047908	3.43662	1.888		7
1993	3	7.88	18.983	15.0406	118.5921	226.2196	12.96584	4.917934	2.967		8
1994	4	12.51	31.4964	25.2397	315.8345	637.0425	20.00359	7.037749	5.476		9
1995	5	16	47.4964	39.4964	631.9424	1559.966	30.07488	10.07129	5.929		10
1996	6	20.2	67.6964	57.5964	1163.447	3317.345	44.48727	14.41239	5.788		11
1997	7	25.7	93.3964	80.5464	2070.042	6487.723	65.11195	20.62468	5.075		12
1998	8	35.3	128.6964	111.0464	3919.938	12331.3	94.62665	29.5147	5.785		13
1999	9	60.1	188.7964	158.7464	9540.659	25200.42	136.8633	42.23665	17.863		14
2000	10	90.2	278.9964	233.8964	21097.46	54707.53	197.3056	60.44225	29.758		15
2001	11	121.3	400.2964	339.6464	41199.11	115359.7	283.8007	86.49516	34.805		16
	12	398.0866	1272.726	1073.682	80116.16	219914.3	407.5786	123.7779		APE	17
2002	13	185.9	S2=				584.7094	177.1308		0.047	18
2003	14	277.2	36.79				838.1903	253.4809		0.086	19
2004	15	400.5					1200.931	362.7408	S1=	0.094	20
		D=	1266264						1.905	MAPE	21
		X=	-0.3584	W/X=	-3.36161				C=	=	22
		W=	1.2048	X1-W/X=	5.571407				0.052	0.076	23

Table4.container throughput forecasting of Ningbo port in 6 original data

		X=	0.6							
year	number	data	S1	S2	S3	a	b	c	forecast	APE
1998	1	20.2	20.2	20.2	20.2	20.2	-3.41061E-16	0		
1999	2	25.7	23.5	22.18	21.388	25.348	0.1064448	1.188	20.200	
2000	3	35.3	30.58	27.22	24.8872	34.9672	0.23749632	2.311	26.642	
2001	4	60.1	48.292	39.8632	33.8728	59.1592	0.58116096	5.486	37.516	
2002	5	90.2	73.4368	60.00736	49.55354	89.84186	0.829915546	6.695	65.227	
2003	6	121.3	102.1547	85.29578	70.99888	121.5757	0.917935718	5.765	97.367	
2004	7	185.9						MAPE	128.258	0.310069
2005	8	277.2						=	146.470	0.471609
2006	9	400.5						0.447	176.211	0.560022
year	number	data	forecast	APE	MAPE					
1998	1	20.2	18.56813		0.041					
1999	2	25.7	27.12203							
2000	3	35.3	39.61653							
2001	4	60.1	57.86695							
2002	5	90.2	84.52492							
2003	6	121.3	123.4636							
2004	7	185.9	180.3404	0.031						
2005	8	277.2	263.4191	0.052						
2006	9	400.5	384.7703	0.041						
year	number	x	y	z	xz	zz	yt	forecast		
1998	0	81	81				81	81		
1999	1	103.3	184.3	132.65	13702.75	17596.02	177.612883	96.61288	6.68711699	
2000	2	121.3	305.6	244.95	29712.44	60000.5	301.5175056	123.9046	-2.6046226	
2001	3	154.2	459.8	382.7	59012.34	146459.3	460.4233887	158.9059	-4.7058831	
2002	4	212	671.8	565.8	119949.6	320129.6	664.2178813	203.7945	8.20550741	
2003	5	263.9	935.7	803.75	212109.6	646014.1	925.5813651	261.3635	2.53651618	
	6	854.7	2557.2	2129.85	434486.7	1190200	1260.776246	335.1949		APE
2004	7	341					1690.658824	429.8826		0.261
2005	8	423.9	59.41				2241.977001	551.3182	2.024	0.301
2006	9	514					2949.034575	707.0576		0.376
			1414737						5.039	MAPE
			-0.2488		-261.01					0.312
			64.9393		342.01				C=	
									0.085	

Table5.container throughput forecasting of Fuzhou port in 12 original data

A	B	C	D	E	F	G	H	I	J	K
container throughput forecasting of FuZhou port in third exponential smoothing and 12 original data										
		X=	0.3							
year	number	data	S1	S2	S3	a	b	c	forecast	APE
1990	1	2.91	2.9103	2.9103	2.9103	2.9103	0	0		
1991	2	3.68	3.14196	2.979798	2.931149	3.417635	0.04255	0.020849	2.9103	
1992	3	4.57	3.569052	3.156574	2.998777	4.23621	0.100473	0.046778	3.481035	
1993	4	7.67	4.798316	3.649097	3.193873	6.641531	0.276382	0.127469	4.383461	
1994	5	10.39	6.477231	4.497537	3.584972	9.524055	0.446856	0.196003	7.045382	
1995	6	15.1	9.064062	5.867495	4.269729	13.85943	0.693214	0.293657	10.16691	
1996	7	17.7	11.65484	7.603699	5.26992	17.42335	0.808164	0.315434	14.8463	
1997	8	22.5	14.90839	9.795107	6.627476	21.96733	0.969474	0.357365	18.54695	
1998	9	25.2	17.99587	12.25534	8.315834	25.53744	1.001067	0.330802	23.29417	
1999	10	31.8	22.13711	15.21987	10.38704	31.13877	1.186719	0.382852	26.86931	
2000	11	40	27.49598	18.9027	12.94174	38.72157	1.484021	0.483487	32.70834	
2001	12	41.8	31.78718	22.76805	15.88963	42.94705	1.415833	0.393194	40.68908	
2002	13	48.2						MAPE	44.75607	0.071451
2003	14	59.8						=	47.35149	0.208169
2004	15	70.8						0.188	50.7333	0.283428

A	B	C	D	E	1					
container throughput forecasting of FuZhou por					2					
					3					
year	number	data	forecast	APE	4					
1990	1	2.91	3.284905		5					
1991	2	3.68	4.236925		6					
1992	3	4.57	5.464855		7					
1993	4	7.67	7.048661		8					
1994	5	10.39	9.09148		9					
1995	6	15.1	11.72634		10					
1996	7	17.7	15.12483		11					
1997	8	22.5	19.50825		12					
1998	9	25.2	25.16207		13					
1999	10	31.8	32.45445		14					
2000	11	40	41.86029		15					
2001	12	41.8	53.9921		16					
2002	13	48.2	69.6399	0.444811	17					
2003	14	59.8	89.82269	0.502052	18					
2004	15	70.8	115.8548	0.636367	19					
				MAPE	20					
				0.528	21					

A	B	C	D	E	F	G	H	I	J	K
container throughput forecasting of FuZhou port in grey system GM(1,1)and 12 original data										
year	number	x	y	z	xz	zz	yt	forecast		
1990	0	2.91	2.9103				2.9103	2.9103		
1991	1	3.68	6.5928	4.75155	17.49758	22.57723	9.55644	6.64614	-2.96364	
1992	2	4.57	11.1584	8.8756	40.52244	78.77628	17.6773	8.120861	-3.55526	
1993	3	7.67	18.825	14.9917	114.9354	224.7511	27.60011	9.92281	-2.25621	
1994	4	10.39	29.2197	24.02235	249.7051	577.0733	39.72471	12.1246	-1.7299	
1995	5	15.1	44.3197	36.7697	555.2225	1352.011	54.53965	14.81494	0.285059	
1996	6	17.7	62.0197	53.1697	941.1037	2827.017	72.6419	18.10225	-0.40225	
1997	7	22.5	84.5197	73.2697	1648.568	5368.449	94.76088	22.11898	0.381017	
1998	8	25.2	109.7197	97.1197	2447.416	9432.236	121.7879	27.027	-1.827	
1999	9	31.8	141.5197	125.6197	3994.706	15780.31	154.8119	33.02405	-1.22405	
2000	10	40	181.5197	161.5197	6460.788	26088.61	195.1637	40.35181	-0.35181	
2001	11	41.8	223.3197	202.4197	8461.143	40973.73	244.4693	49.30553	-7.50553	
	12	220.4094	912.7338	802.5291	24931.61	102725.5	304.7153	60.246		APE
2002	13	48.2	S2=				378.3293	73.61407		0.527263
2003	14	59.8	12.88				468.2777	89.9484		0.504154
2004	15	70.8					578.1849	109.9072	S1=	0.552361
		D=	485928.1						1.3189	MAPE=
		X=	-0.2004	W/X=	-27.0419				C=	0.528
		W=	5.4192	X1-W/X=	29.95222				0.1024	

Table6.container throughput forecasting of Fuzhou port in 6 original data

		X=	0.35							
year	number	data	S1	S2	S3	A	B	C	forecast	APE
1998	1	17.7	17.7	17.7	17.7	17.7	0	0		
1999	2	22.5	19.38	18.288	17.9058	21.1818	0.25978	0.2058	17.7	
2000	3	25.2	21.417	19.38315	18.42287	24.52442	0.429654	0.311272	21.64738	
2001	4	31.8	25.05105	21.36692	19.45329	30.50569	0.74029	0.513342	25.26535	
2002	5	40	30.28318	24.48761	21.2153	38.60202	1.107427	0.731598	31.75932	
2003	6	41.8	34.31407	27.92687	23.56435	42.72595	1.055544	0.587037	40.44105	
2004	7	48.2						MAPE	44.36853	0.079491
2005	8	59.8						=	47.18518	0.21095
2006	9	70.8						0.189	51.17591	0.277176
		year	number	data	forecast	APE	MAPE			
		1998	1	17.7	18.21711		0.074787			
		1999	2	22.5	21.7815					
		2000	3	25.2	26.04331					
		2001	4	31.8	31.139					
		2002	5	40	37.23172					
		2003	6	41.8	44.51655					
		2004	7	48.2	53.22675	0.09444				
		2005	8	59.8	63.6412	0.060357				
		2006	9	70.8	76.09336	0.069564				
year	number	x	y	z	xz	zz	yt	forecast		
1998	0	17.7	17.7				17.7	17.7		
1999	1	22.5	40.2	28.95	651.375	838.1025	40.31953	22.61953	-0.11953	
2000	2	25.2	65.4	52.8	1330.56	2787.84	66.95686	26.63733	-1.43733	
2001	3	31.8	97.2	81.3	2585.34	6609.69	98.32566	31.3688	0.431203	
2002	4	40	137.2	117.2	4688	13735.84	135.2663	36.94069	3.059309	
2003	5	41.8	179	158.1	6608.58	24995.61	178.7686	43.50229	-1.70229	
	6	161.3	519	438.35	15863.86	48967.08	229.998	51.2294		APE
2004	7	48.2					290.3271	60.32905		0.25164
2005	8	59.8	7.7				361.3721	71.04501		0.188044
2006	9	70.8					445.0365	83.66441		0.181701
			52684.69						1.7037	MAPE
			-0.1635		-109.644				C=	0.207
			17.9268		127.344				0.2213	

Table7.container throughput forecasting of Guangzhou port in 12 original data

A	B	C	D	E	F	G	H	I	J	K
container throughput forecasting of GuangZhou port in third exponential smoothing and 12 original data										
		X=	0.45							
year	number	data	S1	S2	S3	a	b	c	forecast	APE
1990	1	11.02	11.0204	11.0204	11.0204	11.0204	-4.8E-16	0		
1991	2	16.19	13.344515	12.06625	11.49103	15.325823	0.222507	0.470633	11.0204	
1992	3	18.04	15.457798	13.59245	12.43667	18.032721	0.267639	0.475003	16.01896	
1993	4	18.76	16.943204	15.10029	13.6353	19.164046	0.206142	0.252992	18.77536	
1994	5	22.07	19.250397	16.96784	15.13494	21.982621	0.251996	0.301014	19.62318	
1995	6	51.5	33.762718	24.52553	19.36071	47.072262	1.42609	2.726124	22.53563	
1996	7	55.8	43.679495	33.14482	25.56356	57.167593	1.321413	1.977082	51.22448	
1997	8	68.7	54.938722	42.95207	33.38839	69.348334	1.334445	1.621984	60.46609	
1998	9	84.1	68.061297	54.25122	42.77667	84.206884	1.455189	1.563443	72.30476	
1999	10	117.7	90.398714	70.51759	55.26008	114.90344	2.322414	3.095142	87.22552	
2000	11	143.1	114.11429	90.13611	70.95429	142.88885	2.660317	3.210793	120.321	
2001	12	173.8	140.97286	113.0126	89.88055	173.76119	2.964173	3.232047	148.76	
2002	13	217.3						MAPE	179.9574	0.171848
2003	14	276.9						=	192.6177	0.304378
2004	15	330.4						0.278	211.7421	0.359134

A	B	C	D	E	1					
container throughput forecasting of GuangZhou port in th					2					
					3					
year	number	data	forecast	APE	4					
1990	1	11.02	10.772159		5					
1991	2	16.19	13.956773		6					
1992	3	18.04	18.082867		7					
1993	4	18.76	23.428773		8					
1994	5	22.07	30.355111		9					
1995	6	51.5	39.329108		10					
1996	7	55.8	50.956121		11					
1997	8	68.7	66.020473		12					
1998	9	84.1	85.538357		13					
1999	10	117.7	110.82639		14					
2000	11	143.1	143.59041		15					
2001	12	173.8	186.04059		16					
2002	13	217.3	241.04048	0.109252	17					
2003	14	276.9	312.3002	0.127845	18					
2004	15	330.4	404.62669	0.224657	19					
				MAPE=	20					
				0.154	21					

A	B	C	D	E	F	G	H	I	J	K
container throughput forecasting of GuangZhou port in grey system GM(1,1)and 12 original data										
year	number	x	y	z	xz	zz	yt	forecast		
1990	0	11.02	11.0204				11.0204	11.0204		
1991	1	16.19	27.2055	19.11295	309.345	365.30486	27.71613	16.69573	-0.51063	
1992	2	18.04	45.2462	36.22585	653.5397	1312.3122	48.98943	21.2733	-3.2326	
1993	3	18.76	64.0049	54.62555	1024.704	2983.9507	76.09537	27.10594	-8.34724	
1994	4	22.07	86.0752	75.04005	1656.156	5631.0091	110.6331	34.53775	-12.4674	
1995	5	51.5	137.5752	111.8252	5758.998	12504.875	154.6403	44.00718	7.492819	
1996	6	55.8	193.3752	165.4752	9233.516	27382.042	210.7132	56.07291	-0.27291	
1997	7	68.7	262.0752	227.7252	15644.72	51858.767	282.16	71.44678	-2.74678	
1998	8	84.1	346.1752	304.1252	25576.93	92492.137	373.1958	91.0358	-6.9358	
1999	9	117.7	463.8752	405.0252	47671.47	164045.41	489.1915	115.9957	1.704334	
2000	10	143.1	606.9752	535.4252	76619.35	286680.14	636.9904	147.7989	-4.69894	
2001	11	173.8	780.7752	693.8752	120595.5	481462.79	825.3123	188.3219	-14.5219	
	12	769.7548	3013.3582	2628.481	304744.2	1126718.7	1065.268	239.9553		APE
2002	13	217.3	S2=				1371.013	305.7454		0.40702
2003	14	276.9	51.92				1760.587	389.5736		0.406911
2004	15	330.4					2256.972	496.3855	S1=	0.502377
		D=	5484994.9						6.837	MAPE=
		X=	-0.2423	W/X=	-49.8737				C=	0.439
		W=	12.0844	X1-W/X=	60.89411				0.1317	

Table8.container throughput forecasting of Guangzhou port in 6 original data

		X=	0.6							
year	number	data	S1	S2	S3	A	B	C	forecast	APE
1998	1	55.8	55.8	55.8	55.8	55.8	6.82E-16	0		
1999	2	68.7	63.54	60.444	58.5864	67.8744	0.249661	2.7864	55.8	
2000	3	84.1	75.876	69.7032	65.25648	83.77488	0.41931	3.88368	70.91046	
2001	4	117.7	100.9704	88.46352	79.1807	116.7013	0.820725	7.254144	88.07787	
2002	5	143.1	126.2482	111.1343	98.35286	143.6944	0.826675	5.247936	124.7762	
2003	6	173.8	154.7793	137.3213	121.7339	174.1079	0.867924	4.20889	149.769	
2004	7	217.3						MAPE	179.1847	0.175404
2005	8	276.9						=	192.6793	0.304156
2006	9	330.4						0.27669	214.5916	0.35051
year	number	data	forecast	APE	MAPE					
1998	1	55.8	55.06438		0.048795					
1999	2	68.7	69.63749							
2000	3	84.1	88.06745							
2001	4	117.7	111.375							
2002	5	143.1	140.8511							
2003	6	173.8	178.1281							
2004	7	217.3	225.2708	0.035383						
2005	8	276.9	284.89	0.028046						
2006	9	330.4	360.2878	0.082955						
year	number	x	y	z	xz	zz	yt	forecast		
1998	0	55.8	55.8				55.8	55.8		
1999	1	68.7	124.5	90.15	6193.305	8127.023	126.0785	70.27854	-1.57854	
2000	2	84.1	208.6	166.55	14006.86	27738.9	214.4427	88.36416	-4.26416	
2001	3	117.7	326.3	267.45	31478.87	71529.5	325.5467	111.104	6.596027	
2002	4	143.1	469.4	397.85	56932.34	158284.6	465.2424	139.6957	3.404304	
2003	5	173.8	643.2	556.3	96684.94	309469.7	640.8876	175.6453	-1.84527	
	6	587.4	1772	1478.3	205296.3	575149.7	861.7338	220.8462		APE
2004	7	217.3					1139.413	277.6792		0.277861
2005	8	276.9	38.27				1488.551	349.1377	0.4625	0.26088
2006	9	330.4					1927.536	438.9855		0.328649
			690377.8						3.9524	MAPE
			-0.229		-217.294				C=	0.289
			49.7603		273.0939				0.1033	

Table9.container throughput forecasting of Nantong port in 12 original data

A	B	C	D	E	F	G	H	I	J	K
container throughput forecasting of NanTong port in third exponential smoothing and 12 original data										
		X=	0.2							
year	number	data	S1	S2	S3	a	b	c	forecast	APE
1990	1	1.09	1.0907	1.0907	1.0907	1.0907	0	0		
1991	2	2.00	1.27254	1.127068	1.097974	1.53439	0.04022	0.007274	1.0907	
1992	3	3.00	1.618952	1.225445	1.123468	2.303989	0.103732	0.018221	1.581883	
1993	4	4.65	2.225842	1.425524	1.183879	3.584831	0.20352	0.034917	2.425942	
1994	5	6.59	3.098653	1.76015	1.299133	5.314643	0.328004	0.054843	3.823268	
1995	6	8.7	4.218923	2.251905	1.489688	7.390742	0.463587	0.0753	5.69749	
1996	7	9.3	5.235138	2.848551	1.76146	8.921221	0.527157	0.081218	7.929629	
1997	8	12.2	6.62811	3.604463	2.130061	11.201	0.646737	0.096828	9.529596	
1998	9	13	7.902488	4.464068	2.596862	12.91212	0.69399	0.098201	11.94457	
1999	10	15.8	9.481991	5.467653	3.17102	15.21403	0.784841	0.107357	13.70431	
2000	11	18.2	11.22559	6.619241	3.860664	17.67972	0.873766	0.115486	16.10623	
2001	12	18.4	12.66047	7.827487	4.654029	19.15299	0.856011	0.103721	18.66897	
2002	13	20.5						MAPE	20.11272	0.018892
2003	14	24.7						=	21.27989	0.138466
2004	15	28.7						0.122667	22.65451	0.210644

A	B	C	D	E	1
container throughput forecasting of NanTong port in th					2
					3
year	number	data	forecast	APE	4
1990	1	1.09	0.9357		5
1991	2	2.00	2.160879		6
1992	3	3.00	3.525823		7
1993	4	4.65	4.99027		8
1994	5	6.59	6.533455		9
1995	6	8.7	8.142434		10
1996	7	9.3	9.808272		11
1997	8	12.2	11.52439		12
1998	9	13	13.2857		13
1999	10	15.8	15.08817		14
2000	11	18.2	16.92849		15
2001	12	18.4	18.8039		16
2002	13	20.5	20.71206	0.010344	17
2003	14	24.7	22.65094	0.082958	18
2004	15	28.7	24.6188	0.142202	19
				MAPE=	20
				0.078501	21

A	B	C	D	E	F	G	H	I	J	K
container throughput forecasting of NanTong port in grey system GM(1,1)and 12 original data										
year	number	x	y	z	xz	zz	yt	forecast		
1990	0	1.09	1.0907				1.0907	1.0907		
1991	1	2.00	3.0906	2.09065	4.181091	4.370817	5.28134	4.19064	-2.19074	
1992	2	3.00	6.0952	4.5929	13.79983	21.09473	10.22029	4.938954	-1.93435	
1993	3	4.65	10.7486	8.4219	39.19047	70.9284	16.04119	5.820892	-1.16749	
1994	4	6.59	17.3385	14.04355	92.54559	197.2213	22.9015	6.860316	-0.27042	
1995	5	8.7	26.0385	21.6885	188.69	470.391	30.98685	8.085348	0.614652	
1996	6	9.3	35.3385	30.6885	285.4031	941.784	40.51598	9.529131	-0.22913	
1997	7	12.2	47.5385	41.4385	505.5497	1717.149	51.74671	11.23073	0.969273	
1998	8	13	60.5385	54.0385	702.5005	2920.159	64.98288	13.23617	-0.23617	
1999	9	15.8	76.3385	68.4385	1081.328	4683.828	80.58261	15.59973	0.200271	
2000	10	18.2	94.5385	85.4385	1554.981	7299.737	98.96795	18.38534	-0.18534	
2001	11	18.4	112.9385	103.7385	1908.788	10761.68	120.6363	21.66837	-3.26837	
	12	111.8478	490.5424	434.6185	6376.958	29088.34	146.174	25.53764		APE
2002	13	20.5	S2=				176.2718	30.09784		0.468188
2003	14	24.7	5.56				211.7442	35.47235		0.436128
2004	15	28.7					253.5507	41.80657	S1=	0.456675
		D=	131078.5						1.0448	MAPE=
		X=	-0.1643	W/X=	-22.3774				C=	0.453663
		W=	3.6766	X1-W/X=	23.46806				0.1879	

Table10.container throughput forecasting of Nantong port in 6 original data

		X=	0.3							
year	number	data	S1	S2	S3	a	b	c	forecast	APE
1998	1	9.3	9.3	9.3	9.3	9.3	-2.6E-16	0		
1999	2	12.2	10.17	9.561	9.3783	11.2053	0.159799	0.0783	9.3	
2000	3	13	11.019	9.9984	9.56433	12.62613	0.238661	0.10773	11.4434	
2001	4	15.8	12.4533	10.73487	9.915492	15.07078	0.381675	0.165132	12.97252	
2002	5	18.2	14.17731	11.7676	10.47113	17.70025	0.501609	0.204471	15.61759	
2003	6	18.4	15.44412	12.87056	11.19095	18.91164	0.468508	0.164196	18.40633	
2004	7	20.5						MAPE	19.54434	0.046618
2005	8	24.7						=	20.50544	0.16982
2006	9	28.7						0.152344	21.79493	0.240595
year	number	data	forecast	APE	MAPE					
1998	1	9.3	9.7476		0.085041					
1999	2	12.2	11.6419							
2000	3	13	13.5362							
2001	4	15.8	15.4305							
2002	5	18.2	17.3248							
2003	6	18.4	19.2191							
2004	7	20.5	21.1134	0.029053						
2005	8	24.7	23.0077	0.073554						
2006	9	28.7	24.902	0.152518						
year	number	x	y	z	xz	zz	yt	forecast		
1998	0	9.3	9.3				9.3	9.3		
1999	1	12.2	21.5	15.4	187.88	237.16	21.55404	12.25404	-0.05404	
2000	2	13	34.5	28	364	784	35.25486	13.70082	-0.70082	
2001	3	15.8	50.3	42.4	669.92	1797.76	50.57327	15.31841	0.481586	
2002	4	18.2	68.5	59.4	1081.08	3528.36	67.70027	17.12699	1.073009	
2003	5	18.4	86.9	77.7	1429.68	6037.29	86.84936	19.1491	-0.7491	
	6	77.6	261.7	222.9	3732.56	12384.57	108.2593	21.40995		APE
2004	7	20.5					132.197	23.93772		0.167694
2005	8	24.7	2.57				158.961	26.76395	0.0101	0.083561
2006	9	28.7					188.8848	29.92385		0.042643
			12238.44						0.6983	MAPE
			-0.1116		-94.4901					0.097966
			10.5451		103.7901				C=	
									0.2717	