

Prediction of Patent Number of "Specialized, Refinement, Differential and Innovation" Little Giant Enterprises in Jiangsu Province based on GM (1.1) Mode

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Abstract: The number of patents is an important index to measure the technological innovation ability of an enterprise. If the most accurate as possible predictions can be made about the number of corporate patents in the region, It has a positive significance for the future economic development and policy formulation of the region, This paper uses the gray GM (1.1) model to predict the patent number of listed companies in the "specialization, refinement, characteristics and novelty" Little giant enterprises in Jiangsu Province, Using the 7-year data from 2013-2020 as raw data for grey predictions, Establish the prediction model of patent number of "Specialized, Refinement, Differential and Innovation" Little giant enterprises in Jiangsu Province, Model tests were also performed using residual estimation, And the patent number prediction model of "Specialized ,Refinement, Differential and Innovation" Little giant enterprises in Jiangsu Province has been successfully established.

1 INTRODUCTION

Specialized, Refinement, Differential and Innovation "little giant" enterprises are the leaders among small and medium-sized enterprises. They are focused on market segmentation, strong innovation ability, high market share, grasp the key core technologies, excellent quality and efficiency of the vanguard enterprises, with the characteristics of "specialization, refinement, characteristics and novelty" (Lu, Gao, 2020; Dong, Li, 2021)⁰. By the end of 2021, the Ministry of Industry and Information Technology had cultivated 4,762 national Specialized, Refinement, Differential and Innovation "little giants" enterprises. This paper predicts the number of listed Little giant enterprise patents by GM (1.1) model in Jiangsu Province.

2 GM (1.1) MODEL CONSTRUCTION

The basic idea of GM (1.1) model is that the original sequence is generated once. Due to the accumulated

sequence has an exponential growth trend, the approximate first-order differential equation is used to establish the model, and finally the modeling sequence is reduced to complete the prediction of the development trend of the original sequence (Xiao, He, 2021).

The original sequence is:

$$X(0) = \{x(0)(1), x(0)(2), \dots, x(0)(n)\}$$

$X(0)$ Next, add up to generate as follows:

$$X^{(1)}(K) = \sum_{i=1}^K X(0)(i), K = 1, 2, 3, \dots, n \quad (1)$$

A sequence with exponential laws is generated as follows:

$$X^{(1)} = \{X^{(1)}(1), X^{(1)}(2), \dots, X^{(1)}(n)\}$$

Grasp $X(1)$ The sequence is approximately the solution of the first-order differential equations.

$$\frac{dx^{(1)}}{dt} + ax^{(1)} = b \quad (2)$$

A is the development coefficient of the model; b is the ash action amount

$A = [a, b]^T$ Parameters, using the least squares method to obtain A as:

$$A = (B^T B)^{-1} B^T Y \tag{3}$$

In formula:

$$B = \begin{pmatrix} -\frac{1}{2}[X^1(1) + X^{(1)}(2)] & 1 \\ -\frac{1}{2}[X^1(2) + X^{(1)}(3)] & 1 \\ \vdots & \\ -\frac{1}{2}[X^1(n-1) + X^{(1)}(n)] & 1 \end{pmatrix}$$

$$Y = \{X^0(2), X^0(3) \dots X^0(n)\}^T$$

The obtained a and b values are inserted into formula (2) to calculate:

$$\hat{X}^1(K+1) = [X^0(1) - \frac{b}{a}]e^{-ak} + \frac{b}{a} \tag{4}$$

Prediction function subtracted by formula (4):

$$\hat{X}^{(0)}(K+1) = \hat{X}^{(1)}(K+1) - \hat{X}^{(1)}(k) = (1 - e^a) \left[X^0(1) - \frac{b}{a} \right] e^{-ak} \tag{5}$$

3 THE DEVELOPMENT STATUS OF SPECIALIZED, REFINEMENT, DIFFERENTIAL AND INNOVATION "LITTLE GIANT" ENTERPRISES IN JIANGSU PROVINCE

Since 2011, the Ministry of Industry and Information Technology first put forward the concept of specialization, refinement, characteristics and novelty "little giant" enterprises, the central and local governments have continuously issued policies to support specialization, refinement, characteristics and novelty "little giant" enterprises, phased certification and listed many batches of national, provincial and prefecture-level specialization, refinement, characteristics and novelty "little giant" enterprises. By the end of 2021, Jiangsu province had cultivated 289 Specialized, Refinement, Differential and Innovation "little giant" enterprises, ranking the fourth in China in total.

There are 731 listed companies of Specialized, Refinement, Differential and Innovation "little giants" in China, and 73 are listed companies in Jiangsu province, accounting for about 10% of the total, ranking the second.

Table 1: Distribution of "Specialized, Refinement, Differential and Innovation" enterprises.

Province	Quantity	Province	Quantity
Zhejiang Province	475	Chongqing City	124
Guangdong Province	433	Shaanxi Province	114
Shandong	369	Shanxi	113
Jiangsu Province	289	The Guangxi Zhuang Autonomous Region	84
Beijing Municipality	264	Yunnan Province	61
Shanghai Municipality	262	Guizhou Province	53
Hunan Province	241	Gansu Province	49
Anhui Province	235	Xinjiang Uygur Autonomous Region	48
Fujian Province	227	Heilongjiang Province	42
Henan Province	212	Jilin Province	38
Liaoning Province	212	The Ningxia Hui Autonomous Region	37
Sichuan Province	212	The Nei Monggol Autonomous Region	27
Hebei Province	210	Hainan Province	17
Hubei province	177	Qinghai Province	11
Jiangxi Province	151	Xizang Autonomous Region	2
Tianjin Municipality	133		

The number of Specialized, Refinement, Differential and Innovation "Little giant" enterprises and listed companies in various prefecture-level cities in Jiangsu Province are shown in the following table.

Table 2: The status quo of Specialized, Refinement, Differential and Innovation "little giant" enterprises in Jiangsu Province.

	The number of enterprises	Number of listed companies	Number of listed companies/enterprises
Jiangsu Province	289	73	25.26%
Changzhou City	28	8	28.57%
Huai'an City	12	0	0.00%
Lianyungang City	9	1	11.11%
Nanjing City	45	15	33.33%
Nantong City	27	6	22.22%
Suzhou City	48	21	43.75%
Suqian city	11	1	9.09%
Taizhou City	21	1	4.76%
Wuxi City	32	12	37.50%
Xuzhou Citey	6	3	50.00%
Yancheng	15	4	26.67%
Yangzhou City	23	0	0.00%
Zhenjiang City	12	1	8.33%

As can be seen from the table, the average listing rate of specialized "little giant" enterprises in Jiangsu Province is 25.26%; the listing rate in Suzhou City is 43.75%, ranking the first in Jiangsu Province, followed by Nanjing City (33.33%).

4 JIANGSU PROVINCE SPECIALIZED AND SPECIAL NEW "LITTLE GIANT" LISTED COMPANY PATENT NUMBER FORECAST

After collecting the number of 2014-2021 patents of the specialization, refinement, characteristics and novelty "little giant" listed companies in Jiangsu Province, the level ratio table is established according to the GM (1,1) model;

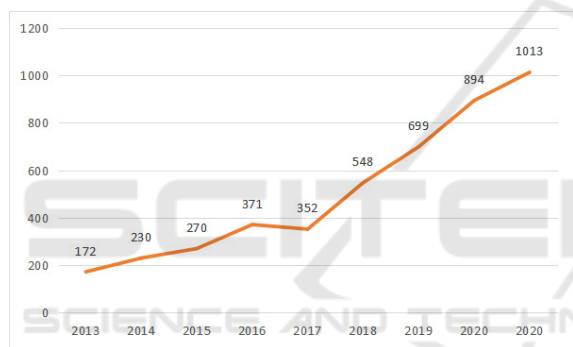


Figure 1: Patent number of "Specialized, Refinement, Differential and Innovation" listed companies in Jiangsu Province.

Table 3: GM (1,1) model-level ratio GM (1,1) model-level ratio table.

order number	original value	Tier ratio	Original value + translation conversion shift value (shift=1013)	Converted value and the ratio
2013	172.000	-	1185.000	-
2014	230.000	0.748	1243.000	0.953
2015	270.000	0.852	1283.000	0.969
2016	371.000	0.728	1384.000	0.927
2017	352.000	1.054	1365.000	1.014
2018	548.000	0.642	1561.000	0.874
2019	699.000	0.784	1712.000	0.912
2020	894.000	0.782	1907.000	0.898
2021	1013.000	0.883	2026.000	0.941

As can be seen from the above table, the GM (1,1) model construction is conducted for the number of patents, and the level ratio test is first conducted to judge the suitability and applicability of the data

sequence for the model construction. The level ratio is the data of the last period / the current period. The results show that the original data did not pass the level ratio test, so the translation transformation, that is, the translation conversion value of 1013.00 is added to the original value, and the final translation conversion data level ratio test value is within the standard range interval [0.819, 1.221], which means that this data is suitable for GM (1,1) model construction.

Table 4: Results of model construction.

Model building results			
developmental quotient a	The amount of action in gray b	The posterior difference is compared to the C value	Small-error probability p-value
-0.0767	1037.6652	0.0297	1.000

According to the above table, the development coefficient a, the gray action amount b, the posterior ratio C value and the small error probability p-value are obtained; the posterior difference ratio C value is $0.030 \leq 0.35$, which means that the model accuracy level is very good. Also, the small error probability p-value is $1.000 < 1.0$, meaning that the model accuracy is very good.

The GM (1,1) model is used to predict the specific number of patents of listed companies in Jiangsu Province in the next five years after 2021, as shown below.

Table 5: Prediction results.

order number	original value	predicted value
2013	172.000	172.000
2014	230.000	159.912
2015	270.000	253.380
2016	371.000	354.295
2017	352.000	463.253
2018	548.000	580.893
2019	699.000	707.907
2020	894.000	845.043
2021	1013.000	993.108
Back phase 1	-	1152.971
Back phase 2	-	1325.573
Back phase 3	-	1511.930
Back phase 4	-	1713.137
Back phase 5	-	1930.379

RMSE=147.643

This paper establishes a patent application quantity prediction model based on the grey system theory (Ma, Song, 2021)⁰ According to the forecast

results, the total number of patents in Jiangsu province in the next five years shows an upward trend. Based on the forecast results of GM (1.1) model, the number of patents of 73 listed "Specialized, Refinement, Differential and Innovation" enterprises in Jiangsu Province will increase from 2022 to 2027 from 993 to 2027, an increase of 1.94 times in 5 years, with an average annual increase of 187.

5 CONCLUSION

"Specialized, Refinement, Differential and Innovation" enterprises have strong scientific and technological innovation ability. From the perspective of Jiangsu Province, the patent number of "specialized, Specialized, Refinement, Differential and Innovation" enterprises currently shows exponential growth and has extremely strong development potential. In the context of the national strong transformation of scientific and technological achievements, the government needs to create a better business environment for "Specialized, Refinement, Differential and Innovation" enterprises to further achieve high-quality development.

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