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Profitability prediction in thermal power enterprise based on the improved system dynamics model

This paper tries to improve the system dynamics model and to establish the model of the thermal power enterprise profitability by using Newton interpolation method to optimize the nonlinear function, MATLAB to fitting equation and data analysis; and through the VENSIM to present a simulation. The model is dissertated and validated by some thermal power enterprise's financial data. This model can provide enterprises with management decision-making reference.

Keywords: Improved system dynamics model, thermal power enterprises, profitability, prediction

1.0 Introduction

The thermal power enterprise is a major industry of China's electric power development, but in recent years, the rapid development of new energy coal market is now under constant pressure. The market continued to weakness, overcapacity, and a single means of competition, make thermal power enterprise competition benefits falling sharply [1-2]. In such circumstances, how to grasp the opportunity and meet the challenge, how to effectively predict the enterprise profitability, find out the main factors affecting the change, realize the optimal allocation of resources, improve the efficiency of the enterprise management, become the much-needed attention to minimize the problems.

2.0 The overview of traditional financial forecast method

In actual work, the financial forecast method can be applied in enterprise capital requirements, all kinds of cost prediction, operating income and the enterprise investment profit forecast, etc. Traditional financial forecasting methods mainly include sales percentages method, regression analysis method, the interactive financial planning, etc. [3-5]. However, the traditional financial forecasting methods cannot dynamically reflect the strategic decision, not establish a relationship between the variables, integrity is not enough [6]. To ensure accuracy, most methods need to support a large number of business data. Therefore, study that uses a small amount of data to predict long-term, periodic, nonlinear, time lag of financial indicators, and through multiple feedback mechanism reflected in the related model needs to strengthen the depth and breadth.

3.0 The financial forecast method based on system dynamics

System dynamics based on system theory, cybernetics and information theory, by means of computer simulation technology, through the different parameters or factors in the model input, to dynamically observe the simulation results of the research object, based on the system internal elements of causal feedback characteristics, from the internal structure of the system to find the root of the problem, is suitable for processing complex, dynamic and nonlinear relationship of enterprise in financial management [7].

At present, in the financial aspects of the system dynamics research is mainly concentrated in the financial early warning, operating results, financial evaluation and financial decisions, etc. [8-9], However, related research is not much, and the research is very little in terms of profitability. This paper introduces the system dynamics theory in financial index prediction, using VENSIM to build models, adopting Newton interpolation method combined with MATLAB to curve fitting and data analysis, which finally through the model simulation to enhance the financial indicators in the dynamics of financial projections and create a financial forecast in new development direction.

4.0 The profitability forecast model based on system dynamics

4.1 Establish profitability forecast model system flowchart

4.1.1 Basic assumptions

Thermal power enterprise is at the mature stage with the production and business operation stability; electricity selling is the main source of income, without heat income and other income. The cost of sales is given priority to with generating cost, and is composed of fuel cost and fixed cost, the cost of raw materials, water, etc. [10], because of little change in every year, expressed as constant in the fixed assets, increase for

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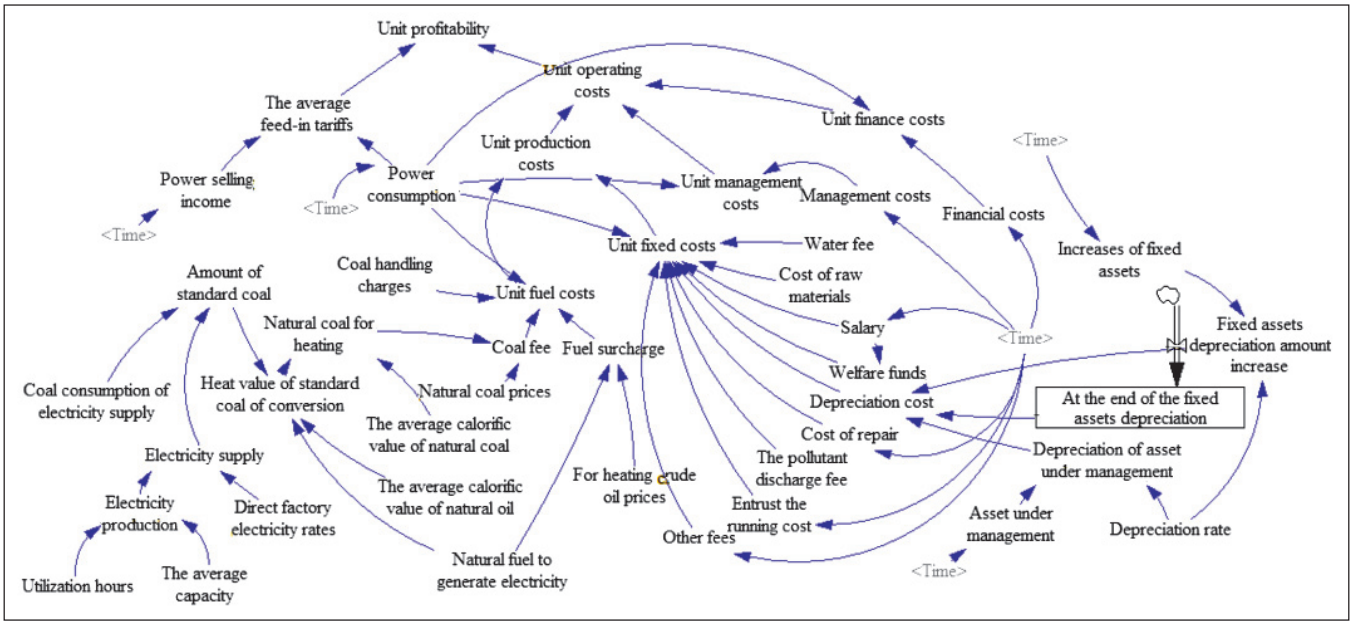

Fig.1: Profitability forecast model for thermal power enterprises

the year depreciation, calculated by half a year, without scrapping fixed assets.

4.1.2 The relationship between the variables and the construction of the model

Combining with the relevant theory of system dynamics, using VENSIM to build thermal power enterprise profitability forecast model, as is shown in Fig.1.

The relationship between the relevant variables is shown in Table 1.

5.0 The empirical research of thermal power enterprise profitability forecast model

To verify the feasibility of the model, the paper, taking certain thermal power enterprises in Hebei province as an example, carry out empirical research. The enterprise was founded in 1994, is one of the main north China power grid power generation company, under the national macroeconomic policy for energy conservation and emissions reduction, the company constantly integrates industry, adjusts strategy and the development is relatively stable.

5.1 Constant value table

On the basis of profitability forecasting model, those variables that have no changes in a year or have little effect on overall is expressed as a constant as is shown in Table 2.

5.2 Fitting function of nonlinear relationship

The essence of the representation of traditional table function is nonlinear approximation as piecewise linear relations, but the traditional table function nonlinear relationship among variables cannot be directly reflected in the model by means of analytic expression, leading to not further to analyze the main structure, oscillation mechanism [11].

Therefore, this paper uses the heritage of Newton interpolation polynomial algorithm for the representation of traditional table function optimization; interpolation method is to use function in a certain range of several points of function value, make appropriate specific function [12]. If this particular function is a polynomial, it is called interpolation polynomial, by using the Newton interpolation method to evaluate the difference quotient, the recursive obtained a formula:

$$f(x) = f[x0]+f[x0, x1](x–x0)+f[x0, x1, x2](x–x0)(x–x1) + \ldots f[x0, \ldots xn](x–x0) \ldots (x–xn–1)+Rn(x)$$

The algorithm can establish unified analytical expression of the nonlinear relationship. Finally the simulation results will be obtained in the form of curve, a large number of simulation practice tells us that the curve relationship can better reflect the nonlinear feature between variables, so as to improve the SD model of the scientific nature and accuracy of the simulation results.

Using the Newton interpolation method for curve fitting of data nodes, and through MATLAB to obtain the curve equation are described in this paper. The curve analytic expression of nonlinear variable is shown in Table 3.

For nonlinear variables, using the traditional function table method and Newton interpolation method with the combination of MATLAB fitting equation method are discussed. Taking power selling income as examples, we carry on the comparison with the representation of the shape, as is shown in Fig.2.

TABLE 1: THE FORMULA OF VARIABLES IN PROFITABILITY FORECAST MODEL

The variable name	Formula	Unit
Unit profitability	The average feed-in tariffs - unit operating costs	Yuan/MWh
The average feed-in tariff	Power selling income/power consumption × 10000	Yuan/MWh
Unit operating costs	Unit production costs + Unit management costs + Unit finance costs	Yuan/MWh
Unit production cost	Unit fuel costs + Unit fixed costs	Yuan/MWh
Unit fuel costs	(Fuel surcharge + coal fee + coal handling charges)/Power consumption	Yuan/MWh
Fuel surcharge	Natural fuel to generate electricity × for heating crude oil prices/1.17/10000	Million
Coal fee	Natural coal for heating × natural coal prices/10000	Million
Natural coal for heating	Heat value of standard coal of conversion / The average calorific value of natural coal 7000	Ton
Heat value of standard coal of conversion	Amount of standard coal - Natural oil × the average calorific value of natural oil /7000	Tonne
Amount of standard coal	Coal consumption of electricity supply × Electricity supply/1000	Tonne
Electricity supply	Electricity production - Electricity production × Direct factory electricity rates/100	Thousand KWH
Electricity production	The average capacity × Utilization hours	Thousand KWH
Unit fixed costs	(Water fee + Cost of raw materials + Salary + Welfare funds + Depreciation cost + Cost of repair + The pollutant discharge fee + Entrust the running cost + Other fees)/Power consumption	Million
Welfare funds	Salary × 0.14 × (1-0.14)	Million
Depreciation cost	Fixed assets depreciation amount increase + At the end of the fixed assets depreciation + Depreciation of asset under management	Million
Fixed assets depreciation amount increase	Increases of fixed assets × Depreciation rate × 6/12	Million
At the end of the fixed assets depreciation	Integ (Fixed assets depreciation amount increase; Initial value of fixed assets depreciation)	Million
Depreciation of asset under management	Asset under management × Depreciation rate	Million

TABLE 2: THE CONSTANT VALUE OF PROFITABILITY FORECAST MODEL

The variable name	Constant value	Unit
For heating crude oil prices (tax amount)	6000	Yuan/tonne
Natural coal prices	279	Yuan/tonne
Natural fuel to generate electricity	800	Tonne
The average calorific value of natural oil	10000	Kilocalorie
The average calorific value of natural coal	5420	Kilocalorie
Coal consumption of electricity supply	335	G/kWh
The average capacity	700	Megawatt
Utilization hours	5300	Hour
Direct factory electricity rates	7.15	%
Coal handling charges	336	Million
Water fee	266	Million
Cost of raw materials	1450	Million
The pollutant discharge fee	891	Million
Initial value of fixed assets depreciation	20055	Million
Depreciation rate	5.53	%

TABLE 3: CURVE ANALYTIC EXPRESSIONS OF NONLINEAR VARIABLE

The variable name	Curve analytic expression	Unit
Power selling income	26210×exp(–((Time-2005)/1.467)^2)+114100×exp(–((Time-2019)/42.93)^2)	Million
Power consumption	663300×exp(–((Time-2005)/1.485)^2)+4.423e+006×exp(–((Time-2007)/11.33)^2) –1.025e+006×exp(–((Time-2008)/3.539)^2)	Thousand KWH
Cost of repair	2995–780.9×sin(Time×2.728+1.57×2.728)+227.8×sin(Time×2.728)	Million
Other fees	4229×exp(-((Time-2003)/0.7426)^2)+4036×exp(–((Time-2012)/19.62)^2)	Million
Management cost	6903×exp(-((Time-2013)/12.06)^2)+9028×exp(-((Time-2005)/0.3116)^2)	Million

5.3 THE MODEL SIMULATION

Running the above established profitability forecast model, we get the simulation result, as is shown in Fig.3.

Contrasting model predicted values and the enterprise real data, the enterprise's profitability model prediction error values from 2010 to 2014 are shown in Table 4

The paper uses MATLAB to establish a relative error curve, as shown in Fig.4, through the curve fluctuation to estimate the reliability of the numerical model prediction.

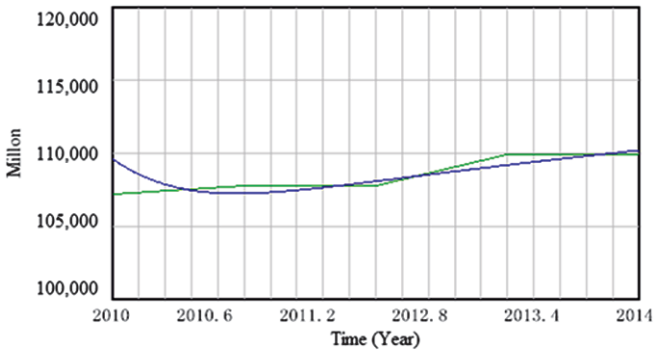

Fig.2: The comparison to the representation of the shape

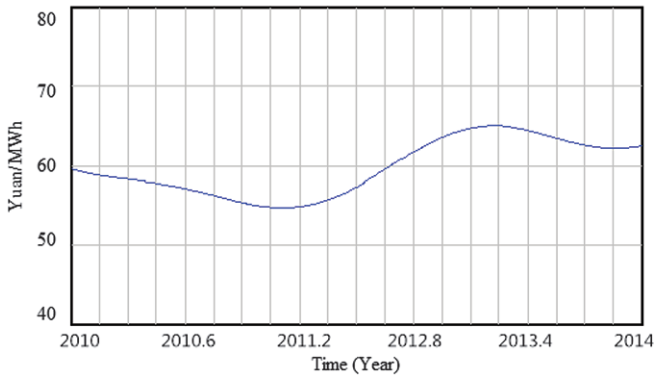

Fig.3: Profitability forecast results

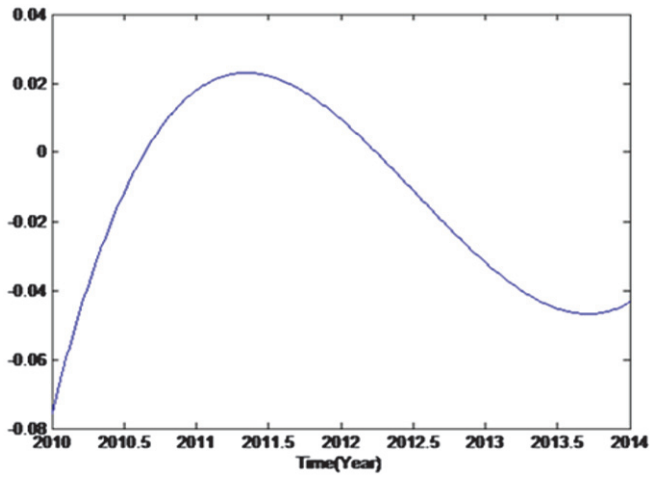

Fig.4: The relative error curve of the profitability

5.4 Model analysis

From Table 4 and Fig.4, the prediction error of the simulation model can be controlled within 10%, in comparison with the actual value, the difference is reasonable, and are constantly decreasing since 2011, with the basic control within 5%. As a result, the profitability forecast model based on system dynamics is effective, the system structure of the model can be partly reflected the actual situation, Thermal power enterprises can change one or more variables within the model parameters, to predict the trends and results of future profitability.

Table 4: Comparison of the predicted values and the real value

Time (year)	2010	2011	2012	2013	2014
Actual value	55.4103	57.3488	57.8811	63.0806	59.9239
Simulation value	59.6076	56.3197	57.3227	65.0929	62.5334
Absolute error	-4.1973	1.0291	0.5584	-2.0123	-2.6095
Relative error	-0.0757	0.0179	0.0096	-0.0319	-0.0435

From Fig.3, the annual trends of corporate profitability, which showed a trend of gentle decline from 2010 to 2011; because of the 12th five-year plan from 2011 to 2013, the major national power generation enterprises have guided by the national policy, improving the technology, reducing cost increasing efficiency, adjusting the industrial structure, transforming the traditional energy to new energy, which has realized the transformation of development. This enterprise's profitability has risen steadily from 2011 to 2013, especially in the growth rate in 2011-2012; although there is a slight decline from 2013 to 2014, but it is still higher than the overall level of 2010-2011, and has maintained steady trend.

Combined with the actual situation analysis, the thermal power enterprise's cost per unit is composed of unit fuel costs and fixed costs, among them, the greater influence on the changes of the cost per unit is fixed costs, depreciation is the main influencing factors, but the fuel costs occupy more proportion in the cost per unit. In 2014, for example, the unit production cost is RMB 226/MWH, while unit fuel costs is RMB 124/MWH, accounting for about 55% of the proportion. From which, the enterprise should adjust the structure of electric power industry, optimize the development of thermal power, lead to equal emphasis on development and conservation. At the same time, strengthen the construction of the internal management mechanism, improves the efficiency of resource utilization, realizes resource optimal configuration.

In the short term, the gradual marketization of electric power, coal prices and costs continue to fall, making thermal power enterprise's profitability steady. But in recent years, as the social and economic growth are slowing down, electricity demand downturns, feed-in tariff cuts and other reasons, in the long run, electricity market, power generation hours impact on the company's profitability, which will rise considerably, profitability is under pressure.

6.0 Conclusion

This paper improved the financial indicators model based on the theory of the system dynamics, establishing a thermal power enterprise's profitability forecast model, and creatively by using the Newton interpolation method and MATLAB programming to optimize the nonlinear function, and then gets the curve analytic expression of nonlinear variable into the model, which would improve the precision of the model simulation results. By comparing the profitability of the actual value and the predicted value, it is proved that the validity

and scientific of the model, and the results of profitability prediction model will provide reference for enterprise decision-making, having certain practical value and practical significance.

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