# Empirical Study of Integrated EVA Performance Measurement in China[1]

## ÉTUDE EMPIRIQUE SUR EVA INTÉGRÉE DE MESURE DU RENDEMENT EN CHINE

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**Abstract:** Traditional performance measurement has some limitations. Economic Value Added (EVA) is a real method to measure the company's true value. This paper discussed on how to improve traditional performance measurement with EVA. It presented the integrated EVA performance measurement (IEPM) model. The superiority of IEPM model to traditional performance measurement was empirically analyzed with BP neural network and the data from China's listed companies. The results showed that the measurement ability of IEPM model was superior to that of traditional performance measurement. Its prediction ability was also proved to be better than that of traditional measurement. It suggests that introducing EVA to performance measurement well reflects the company's real profit. So it is effective and reasonable to use IEPM model to evaluate and predict the company's performance.
**Key words:** Economic value added, IEPM model, Neural network, Performance measurement

**Résumé:** Traditionnels de mesure du rendement a quelques limitations. Economic Value Added (EVA) est une vraie méthode pour mesurer la vraie valeur de l'entreprise. Ce document discuté sur la manière d'améliorer la mesure du rendement traditionnel avec EVA. Il a présenté les mesures de la performance intégrée EVA (IEPM) modèle. La supériorité de l'IEPM modèle traditionnel de la mesure du rendement a été empiriquement analysées avec BP de réseaux de neurones et les données provenant de la Chine sociétés cotées. Les résultats ont montré que la mesure de la capacité IEPM modèle a été supérieure à celle de la traditionnelle mesure de la performance. Sa capacité de prévision a également été révélée meilleure que celle de la mesure traditionnelle. Il suggère que l'introduction de l'EVA à la mesure du rendement reflète bien la société profit immobilier. Ainsi, il est efficace et raisonnable d'utiliser IEPM modèle pour évaluer et prévoir les résultats de la société.
**Mots-Clés:** Economic value added, IEPM modèle, Neural network, Mesure de la performance

## 1. INTRODUCTION

Performance measurement is a very important factor for solving agency problem. The performance measurement system used in China usually relies on traditional accounting measures. It measures the company's performance from such aspects as accounting profit, assets operation ability, debt paying ability, and growth ability. Traditional accounting measures are easy to be quantized and the data are also easy to be obtained. But there are still some problems with traditional performance measurement. First, its evaluation indices are mainly from the company's

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financial report based on Generally Accepted Accounting Principles (GAAP). Many kinds of preparations, goodwill, deferred taxes and some other items are deduced directly from the income account. So the legal capital is considered to be reduced and some unnecessary financing or investment behavior occurs. Second, debt cost has been reflected in traditional performance measurement, but capital cost is not yet. So the cost calculation is not exact. It couldn't reflect the investors' required minimum attractive rate of return. Third, performance measurement system used in China mostly relies on subjective weighting method. The weights may be influenced by some subjective factors. So the inherent relationships of evaluation indices may be distorted and the results could not reflect the company's real performance. Last, the interests of manager and shareholder couldn't be unified effectively. So manager may pay more attention to short-term achievements and give up those projects that will be good for company's long–term development while may have some negative influence on current profit. The company's future development would also be influenced.

In order to solve the problem, we need performance measures, which could well reflect the shareholder's interest. Economic value added (EVA) is such a method that is viewed as an effective measure reflecting both the value of company and the interest of shareholder[4]. Many researches have shown that EVA better reflects the company's real economic profit than traditional performance measurement[5]. It is the right measure most directly linked to the creation of value for shareholders[6]. But EVA has not been applied to performance measurement system in China yet. This paper will discuss how to introduce EVA into performance measurement system and make some improvement to traditional performance measurement, then set up a model integrating EVA.

The neural network is used here to do the empirical analysis. Performance measurement is often influenced by state policies, social background, economic environment and other factors. It is very complicated and couldn't be described only with ordinary linear regression. However, neural network can solve the problem. Many studies have proved that neural network performs better than linear regression on measuring the company's performance. But no empirical studies of this kind have been conducted in China. What will the result be in China? Will it draw the same conclusion as that of prior studies? This is our paper aiming to do.

The remainder of the paper is organized as follows. Section 2 outlines the concept of EVA and discusses the improvement of EVA to traditional performance measurement. Then integrated EVA performance measurement model is developed. Section 3 presents the empirical methodology for testing the model. Section 4 shows the empirical results. And conclusion is presented in section 5.

## 2. INTRODUCING EVA TO PERFORMANCE MEASUREMENTS

EVA, developed by Stern Stewart and Co., is viewed as an estimation of a company's true economic profit that differs from accounting profits[7]. Based on residual income(RI), Stern Stewart made some adjustments on net operating profits after tax (NOPAT) and invested capital to eliminate the accounting distortions caused by GAAP[8], then put forward EVA:

$$EVA = \left(NOPAT + Adj_{NOPAT}\right) - k \cdot \left(Capital + Adj_{Capital}\right) \tag{1}$$

It shows that EVA equals to net operating profits minus a charge for cost of invested capital. $Adj_{NOPAT}$ and $Adj_{Capital}$ represent the adjustments made by Stern Stewart on NOPAT and capital, and $k$ refers to the rate of capital cost. In fact, EVA measures the company's value creation from the economic points of view. It is believed that EVA is the real method to capture the true economic profit of the company[9]. Some researches showed that EVA had more explanation on the company value and stock returns than traditional accounting indices[10,11,12]. Some proved with economics that incentive scheme based on RI or EVA can effectively eliminate financial risk and reducing agency cost, then optimizing incentive contract[13,14].

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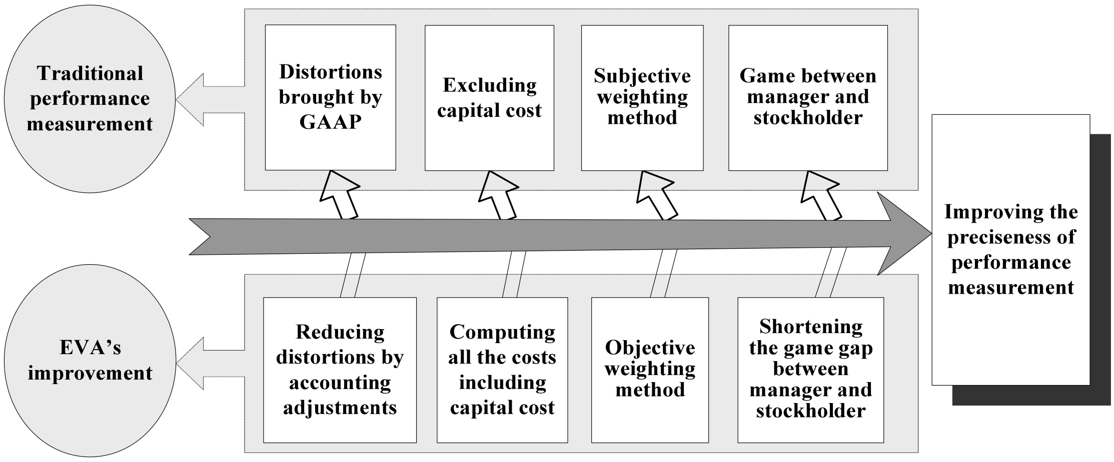


**Fig.1 Improvement of EVA to performance measurement**

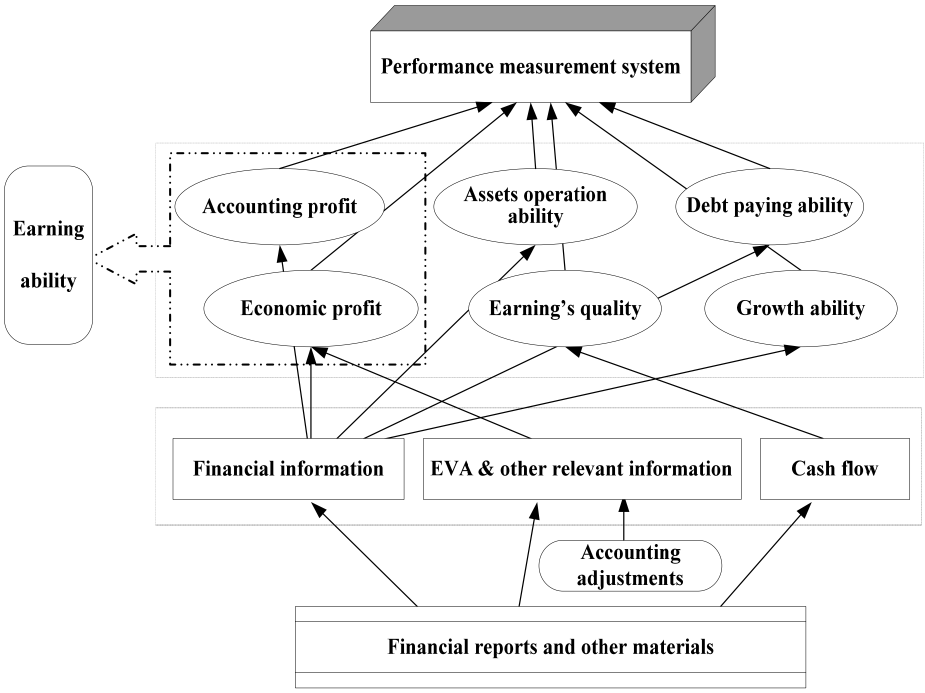


**Fig. 2 Integrated EVA performance measurement model**

Introducing EVA to performance measurement model will make some improvement on traditional performance measurement.

1st. It will reduce distortions caused by GAAP. The company could adjust accounting income and book assets according to manager's influence on the output of special adjustments, the amount of output, ways to get necessary information, and the people's understanding. They added such items as preparations, goodwill, deferred tax back to the capital and make the adjusted data closing to cash flow and well reflecting the company's real performance.

2nd. It will produce more accurate information. Capital cost will be recognized when introducing EVA to performance measurement[15]. It suggests that only when income exceeds all the capital cost, the company's value will grow and the wealth be created. So the value added bringing to shareholder will be quantified. At the same time, capital cost's putting forward will force managers to make better use of current capital.

3rd. Objective weighted method will be used to allocate the weights of indices. Different from traditional subjective weighted method, the paper will use BP neural network to give the weights. It will make

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use of initial weight and threshold function and automatically give the weights by system. Then the weights will be adjusted through training until optimization. Thus subjectivity in the evaluation will be effectively reduced.

4th. The interests of manager and shareholder will be united. Combining EVA and market value will help to conquer manager's risk-aversion and make them pay more attention to capital cost and long-term strategy[16]. Furthermore, the projects helping to creative more value and increase shareholder's interest will be adopted. The gap between manager and shareholder will also be shortened. Agent cost will also be reduced and two-win situation comes into being[17].

The improvement of EVA to performance measurement can be summarized in Fig.1.

Moreover, traditional performance measurement may pay too much attention to accounting profit. Some enterprises did earning management in order to make good-looking accounting reports. So the paper considers adding indices of cash flow to reflect the earning's quality. Therefore, integrated EVA performance measurement (IEPM) model is put forward. (Shown in Fig.2)

Fig.2 shows that IEPM model measures the company's performance just from accounting profit, assets operation ability, debt paying ability, economic profit, earning's quality, and growth ability. The detailed indices include traditional accounting indices, EVA, cash flow, and some relevant ones. They come from financial reports and other materials.

IEPM model not only focuses on financial indices, but also includes EVA and some other indices, reflecting the characteristic of multiple measures. Traditional performance measurement evaluates the company's performance mainly from the point of view of accounting profit. EVA evaluates the performance from the point of view of economic profit. They reflect the company's management and performance from two different sides. Only using one measure is not complete. Combining them will make better.

Next, we will test the superiority of IEPM model to traditional performance measurement.

## 3. EMPIRICAL METHODOLOGY

Neural network will be used here to do the empirical analysis.

Neural network can effectively solve complicated problems that could not be settled by simple calculated principle or which inputs have noises. Neural network has already been used in management fields, such as finance, insurance, securities to do securities grading, market prediction, credit consultation, and etc. In recent years, many foreign studies shows that neural network's application in the area of performance measurement is very successful[18, 19]. For example, Back, Sere and Vanharanta believed that the company's single-period and multi-period performance could be well measured with self-organizing map clustering. At the same time, the performance of different company and different time of the same company would also be well predicted[20]. Zheng and Harrison used the probabilistic neural network to set up a template. They measured the performance and analyzed existing problems through comparing the difference between company and template[21]. Callen, Kwan, Yip, and Yuan analyzed and well predicted the seasonal accounting income with neural network[22]. Desai and Bharati analyzed the differences of prediction ability between BP neural network and linear regression model in predicting extra earnings of large shares. They found that BP neural network is superior to linear regression model at certain confidence level[23].

At present, neural network was scarcely used to measure the company's performance in China. So we try to use this method to do the research. BP neural network will be used here. The arithmetic will be developed through Matlab 7.0.

BP neural network was designed as follows.

### 1st. Input layer

Two groups of input variables are designed according to the requirement. The first group is traditional performance measurement model. It includes

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15 variables respectively reflecting the company's accounting profit, assets operation ability, debt paying ability, and growth ability. The second group is IEPM model. It adds five variables to traditional performance measurement to reflect the company's economic profit and earning's quality (See in Tab.1).

FGV is present value of future increased EVA. It is the extension of EVA. The result of return on capital minus capital cost and ratio of capital cost are both the important components of EVA. Many domestic and foreign researches on EVA pay much attention to these indexes. In addition, we consider four macroscopical influencing factors in input layer to reduce the error.

Input layer has no requirement for variables' order of magnitude. But the weight will be distorted and the error will be enlarged if order of magnitude of different variables is quite different. So the variables such as GDP, money supply, will take the logarithm. And EVA per share and FGV per share will replace the variables EVA and FGV.

**Tab.1 Input variables**

| Group 1: Traditional performance measurement | | | | Group 2: IEPM model | | | |
|---|---|---|---|---|---|---|---|
| No. | Variable | No. | Variable | No. | Variable | No. | Variable |
| 1 | Profit rate of prime operating | 13 | Prime operating revenue increasing rate | 1 | Profit rate of prime operating | 13 | Prime operating revenue increasing rate |
| 2 | Return on investment | 14 | Net assets increasing rate | 2 | Return on investment | 14 | Net assets increasing rate |
| 3 | Return on equity | 15 | Total assets increasing rate | 3 | Return on equity | 15 | Total assets increasing rate |
| 4 | Earnings per share | 16 | GDP | 4 | Earnings per share | 16 | GDP |
| 5 | Accounts receivable turnover | 17 | Money supply (M2) | 5 | Accounts receivable turnover | 17 | Money supply (M2) |
| 6 | Inventory turnover | 18 | Stock Index | 6 | Inventory turnover | 18 | Stock Index |
| 7 | Assets turnover | 19 | Exchange rate | 7 | Assets turnover | 19 | Exchange rate |
| 8 | Current ratio | | | 8 | Current ratio | 20 | Economic value added |
| 9 | Ratio of debts to assets | | | 9 | Ratio of debts to assets | 21 | Future growth value |
| 10 | Current debt ratio | | | 10 | Current debt ratio | 22 | Return on capital - capital cost |
| 11 | Equity Ratio | | | 11 | Equity Ratio | 23 | Capital cost |
| 12 | Net asset per share | | | 12 | Net asset per share | 24 | Operating cash flows per share |

Note: Variable 1~4 reflect accounting profit. Variable 5~7 reflect assets operation ability. Variable 8~12 reflect debt paying ability. Variable 13~15 reflect growth ability. Variable 16~19 reflect macroscopical influencing factors. Variable 20~23 reflect economic profit and variable 24 reflect earning's quality.

## 2nd. Output layer

Output layer will be developed on market evaluation. Total market value plays the role. In order to reduce the error of net learning, market value per share (*MVPS*) will be the replacement. Furthermore, listed companies must finish their annual report within four months from the end of accounting year according to the regulation of China security regulatory commission. So the disclosure of financial indices including EVA will have time lag. The market reflection will have lag too. Then the mean market value per share (*MMVPS*) of next year will be the best replacement.

$$MMVPS_t = (MVPS_{t-1} + MVPS_t)/2 \qquad (2)$$

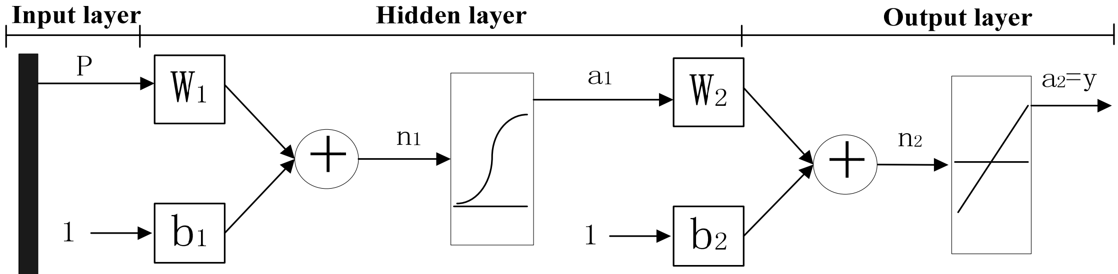
## 3rd. Hidden layer

Hidden layer shows the interaction of input processing unit and internal structure of the problem. The number of hidden layer usually is determined by the complexity of problem. According to experience, the rule used here to determine the node number is as follows.

$$node = 2 * \sqrt{Input + Output} \qquad (3)$$

In formula (3), node represents the node number of hidden layer. Input represents the number of input variables and Output is the number of output variables. The results of calculation show that the nodes of first group are nine and the second group is ten.

Moreover, logarithm sigmoid transfer function, $\log sig(n) = 1/(1+e^{-n})$, will be used in hidden layer. Linear transfer function, $purelin\,(n) = n$, will be used in output layer. Then the structure of BP neural network is determined. (Shown in Fig.3)




$$a_1 = \log sig(W_1 P + b_1) \qquad a_2 = purelin(W_2 \cdot a_1 + b_2)$$

**Fig.3 Structure of BP Neural Network**

## 4th. Algorithm

Standard BP network uses standard gradient descent method when modifying weight and threshold. It means that weight and threshold will be adjusted by negative gradient. Although it is nonlinear optimal question, segment minimum question does exist. Convergence speed of BP algorithm is very slow and the stability of data is bad. So we choose Levenberg- Marquardt algorithm to improve BP network. Suppose that $\omega$ is weight, $b$ is threshold, $t$ is target output, $Q$ is the number of target, $a$ is the output, and $k$ is iterative number, Levenberg-Marquardt algorithm can be described as follows.

$$\boldsymbol{x}_{k+1} = \boldsymbol{x}_k - [\boldsymbol{J}^T(\boldsymbol{x}_k)\boldsymbol{J}(\boldsymbol{x}_k) + \mu_k \boldsymbol{I}]^{-1} \boldsymbol{J}^T(\boldsymbol{x}_k)\boldsymbol{e}(\boldsymbol{x}_k) \tag{4}$$

In formula (4), $\boldsymbol{x}$ is resultant vector of weight and threshold,

$$\boldsymbol{x}^T = [\omega^1_{1,1} \quad \omega^1_{1,2} \quad \cdots \quad \omega^1_{S^1,R} b^1_1 \cdots \quad b^1_{S^1}\omega^2_{1,1} \quad \cdots \quad b^M_{S^M}] \tag{5}$$

$\boldsymbol{e}$ is the error vector,

$$\boldsymbol{e}^T = [e_{1,1} \quad e_{2,1} \quad \cdots \quad e_{S^M,1} \quad e_{1,2} \cdots \quad e_{S^M,Q}] \tag{6}$$

***J(x)*** represents Jacobian matrix, including first order derivative of the network training error.

$$\boldsymbol{J}(\boldsymbol{x}) = \begin{bmatrix} \frac{\partial e_{1,1}}{\partial \omega^1_{1,1}} & \frac{\partial e_{1,1}}{\partial \omega^1_{1,2}} & \cdots & \frac{\partial e_{1,1}}{\partial \omega^1_{S^1,R}} & \frac{\partial e_{1,1}}{\partial b^1_1} & \cdots \\ \frac{\partial e_{2,1}}{\partial \omega^1_{1,1}} & \frac{\partial e_{2,1}}{\partial \omega^1_{1,2}} & \cdots & \frac{\partial e_{2,1}}{\partial \omega^1_{S^1,R}} & \frac{\partial e_{2,1}}{\partial b^1_1} & \cdots \\ \vdots & \vdots & & \vdots & \vdots & \\ \frac{\partial e_{S^M,1}}{\partial \omega^1_{1,1}} & \frac{\partial e_{S^M,1}}{\partial \omega^1_{1,2}} & \cdots & \frac{\partial e_{S^M,1}}{\partial \omega^1_{S^1,R}} & \frac{\partial e_{S^M,1}}{\partial b^1_1} & \cdots \\ \frac{\partial e_{1,2}}{\partial \omega^1_{1,1}} & \frac{\partial e_{1,2}}{\partial \omega^1_{1,2}} & \cdots & \frac{\partial e_{1,2}}{\partial \omega^1_{S^1,R}} & \frac{\partial e_{1,2}}{\partial b^1_1} & \cdots \\ \vdots & \vdots & & \vdots & \vdots & \end{bmatrix} \tag{7}$$

The weight is,

$$[\boldsymbol{J}]_{h,l} = \frac{\partial e_{k,q}}{\partial \omega^m_{i,j}} = \frac{\partial e_{k,q}}{\partial n^m_{i,q}} \times \frac{\partial n^m_{i,q}}{\partial \omega^m_{i,j}} = \tilde{S}^m_{i,h} \times \frac{\partial n^m_{i,q}}{\partial \omega^m_{i,j}} \tag{8}$$

The threshold is,

$$[\boldsymbol{J}]_{h,l} = \frac{\partial e_{k,q}}{\partial b^m_i} = \frac{\partial e_{k,q}}{\partial n^m_{i,q}} \times \frac{\partial n^m_{i,q}}{\partial b^m_i} = \tilde{S}^m_{i,h} \times \frac{\partial n^m_{i,q}}{\partial b^m_i} \tag{9}$$

In formula (8) and (9), $h = (q-1)S^M + k$, $\tilde{S}^m_{i,h} = \partial e_{k,q} \big/ \partial n^m_{i,q}$ is Marquardt sensitivity.

The iterative steps of Levenberg-Marquardt algorithm are as follows.

① Input all the variables into network and calculate the output, error $\boldsymbol{e}_q = \boldsymbol{t}_q - \boldsymbol{a}^M_q$, and sum of all the input variances.

② Calculate Jacobian matrix according to formula

(7), (8) and (9).

③ Compute $\Delta \boldsymbol{x}_k = \boldsymbol{x}_{k+1} - \boldsymbol{x}_k$ according to formula (4).

④ Compute the sum of variances with $\boldsymbol{x}_k + \Delta \boldsymbol{x}_k$ repeatedly. If new sum of variances is lower than that of first step, $\mu$ will be divided by factor $\theta$. Then suppose $\boldsymbol{x}_{k+1} = \boldsymbol{x}_k + \Delta \boldsymbol{x}_k$ and turn to the first step to begin a new calculation. If new sum of variances is not reduced, $\mu$ will be multiplied by $\theta$, and then go to the third step. Levenberg-Marquardt algorithm will not be convergent until sum of variances is reduced to the given target error.

*Trainlm* will be used as the training function when BP neural network is improved by Levenberg-Marquardt algorithm. Weight and threshold will be initialized with *init* function. Finally two convergence conditions are set up. The first one is that target error will be 1e-5. Tde second one is that max learning steps is 3000.

### 5th. Network performance measurement

Mean square error (*mse*) will be used to measure the network performance. Lower *mse* is, lower the network's predicted error will be. Furthermore, linear regression method will be used to analyze the relationship between net output and target output in order to evaluate the net training and its performance. Here *m* represents the slope of optimal regression line; *b* represents intercept of the line in Y axis; *r* is correlation coefficient of real output and target output. If *m* is close to 1, *b* is close to 0 and r close to 1, the difference between output and target will be very small. It's believed that the network performance is very good.

6th. Prediction ability. Prediction ability of the model will be discussed by comparing the predicted results and the real ones. Pearson correlation and mean absolute percentage error (MAPE) are the tools to measure whether the predicted results are good or not. Assume $P_{ij}$ is the predicted result of company $i$ in period $j$. $A_{ij}$ is the real one and $n$ represents total period. MAPE can be calculated as:

$$MAPE_i = \sum_{j=1}^{n} \left| \left(P_{ij} - A_{ij}\right) / A_{ij} \right| \cdot 100\% / n \qquad (10)$$

It shows that lower MAPE is, lower predicted error of the model will be and better predicted ability will be.

## 4. EMPIRICAL ANALYSIS

Samples are selected according to the following rules. ① Companies must come into market in Shanghai and Shenzhen stock exchange. ② Financial information, EVA and other relevant information are complete. ③ Listed companies of ST, PT are excluded for their incorrect information. ④ Listed companies of financial sector are excluded for their special characteristics. Finally, 740 companies are selected. Moreover, data of 2000 and 2001 are chosen because of the restriction of EVA. All the accounting information comes from CSMAR database and giant wave database. EVA came from stockstar network and Stern Stewart & Co.

### 1st. Network capability analysis

The superiority of IEPM model to traditional performance measurement is shown in Table 2.

**Table 2 Network capability analysis**

| Year / Variable | 2000 | | 2001 | |
|---|---|---|---|---|
| | Model 1 | Model 2 | Model 1 | Model 2 |
| *mse* | 9.982e-006 | 5.493e-006 | 9.623e-006 | 5.874e-006 |
| *m* | 0.345 | 0.771 | 0.124 | 0.666 |
| *b* | 0.007 | 0.002 | 0.008 | 0.003 |
| *r* | 0.590 | 0.818 | 0.119 | 0.551 |

Table 2 shows that *mse* of IEPM model is lower than that of traditional performance measurement. It suggests mean square error has been reduced when using IEPM model and the performance of network has been improved. Then the result of linear regression told us that *m* of IEPM model is greater than that of traditional performance measurement, and closer to 1; *b* of IEPM model is lower than that of traditional one. It suggests that the difference between real output and target output decreased. Finally correlation *r* shows that *r* of IEPM model is greater than that of traditional one and closer to 1. It suggests that real output is close to target output when IEPM model was used. The relationship between them becomes stronger than ever.

All these show that network performance has been improved after IEPM model used. It proves that IEPM model is superior to traditional performance measurement. So it will be more effective to measure the company's performance with IEPM model.

### 2nd. Significance testing

First it tests whether the samples fit the normal distribution. From Table 3 we know that sample's skewness is not equal to 0 and kurtosis is not equal to 3. Meanwhile, Asymp. significance of two tails of K-S Z-statistics is 0, lower than 1. So we can draw a conclusion that the samples don't fit the normal distribution.

**Table 3 Normal distribution test**

| Variable | Year | |
|---|---|---|
| | 2000 | 2001 |
| Skewness | 2.332 | 1.321 |
| Kurtosis | 8.646 | 15.117 |
| K-S *Z* | 5.005 | 3.072 |
| Asymp. Sig. | 0.000 | 0.000 |

Then t-test could not be used here. Wilcoxon signed ranks test fit this situation and will be adopted to test the significance of IEPM model. The results are shown in Table 4.

**Table 4 Wilcoxon signed ranks test**

| Variable | Year | |
|---|---|---|
| | 2000 | 2001 |
| *Z* | -8.240 | -2.238 |
| Asymp. Sig. | 0.000 | 0.025 |

The significance of results is 0.000 in 2000 and 0.025 in 2001. It suggests that the results have significant statistical meaning. Then it's believed that IEPM model is significantly different from traditional performance measurement. The difference between them is very clear.

### 3rd. Prediction ability analysis

The result of prediction analysis is shown in Table 5. Comparing predicted results and real ones shows that pearson correlation of IEPM model is higher than that of traditional performance measurement. It suggests predicted results will be very close to real ones if the prediction is based on IEPM model. Furthermore, MAPE of IEPM model is lower than that of traditional measurement. It means predicted error of IEPM model is lower. Its prediction ability is superior to traditional performance measurement. Then IEPM model well predicts the company's performance.

**Table 5 Predicted ability analysis**

| Model | PearsonCorrelation | Sig. (2-tailed) | MAPE |
|---|---|---|---|
| 1 | 0.641 | 0.000 | 0.409 |
| 2 | 0.794 | 0.000 | 0.392 |

So we can draw a conclusion that IEPM model is better than traditional performance measurement. It will be a good choice to using IEPM model to measure and predict the company's performance.

## 5. CONCLUSION

Traditional performance measurement has some limitations and will bring some bad news to manager's decision-making. Introducing EVA to traditional performance measurement and developing the integrated EVA performance measurement model will make better. IEPM model measures the company's performance from the point of view of both economic profit and accounting profit. Its superiority to traditional performance measurement was empirically tested with BP neural network.

The results showed that not only the measurement ability of IEPM model was better than that of traditional measurement, but also the prediction ability was better too. It suggests introducing EVA to performance measurement well reflects the company's real profit. It also shows that neural network can be well applied in the area of performance measurement. The research on performance measurement will have another powerful tool.

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