

Internal Cost Control Evaluation for Manufacturing Enterprises Based on Exergy Economic Analysis –Evidence from C Company

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Abstract. This article describes a new perspective of evaluating internal cost control efficiency for manufacturing enterprises through the efficiency of material, energy, labor and capital to find an efficient way to evaluate the efficiency of the implementation of internal cost control. The conventional way of evaluating the effect of internal cost control implementation is utilizing the enterprise's financial indicators, which are deeply influenced by external environment and cannot fully reflect the operational efficiency improvement. This research introduces exergy economic analysis method from thermodynamics based on a case study of a cable manufacturing Company (C Company), the paper introduces the exergy economic analysis which evaluates internal cost control efficiency in energy, labor and capital utilization from the perspective of energy. In this study, energy, capital and labor are unified into exergy to compare the change and trend after the implementation of internal cost control based on the consumption of those factors of production among 2009-2013. Findings have proved that (1) the exergy economic analysis method could eliminate the negative influence of the financial indicators from external environment; (2) this technique is proved as an efficient way to evaluate the efficiency of the implementation of internal cost control. This method is given us to the possibility of using this new technique to complement the efficiency evaluation of cost control for manufacturing enterprises internal. Moreover, it is a new approach to evaluate the process of the internal cost control implementation.

Introduction

Internal control is an enterprise using some certain means and methods to improve the operational efficiency of the process under certain circumstance. The classic internal control framework is the five elements published by COSO (control environment, risk assessment, control activities, information and communication, and monitoring). Although studies based on the mathematical model of financial auditing and the integrated AHP take and one step forward on quantitative research in this field, they have not directly assessed internal control from the perspective of efficiency. In recent years the exergy economic analysis method under the available energy (factors of production) perspective can explain the effectiveness of internal control and make contributions to improving the operational efficiency of the management. The definition of exergy in engineering thermodynamics is: exergy is the maximum useful work that could be obtained from the system at a given state in a specified environment. The second law of thermodynamics points out that the energy transfer process will inevitably have exergy loss. Exergy efficiency is the efficiency that energy has been actually applied into the production. This study introduces exergy economic analysis on enterprise internal control research based on efficiency to provide a new way of researching in the future.

Literature Review

Exergy can be quantified and analyzed from the perspective of efficiency based on the second law of thermodynamics which contains energy quality. In business management, Szargut [1] and Morris [2] have introduced the concept of accumulation of exergy consumption based on life cycle analysis,

while Sciubba [3-5] proposed the expanding concept of exergy and put labor and capital into exergy, brought exergy concept widely used in the field of economics and management. Keenan pointed out that the economic value of product is exergy content rather than energy [6]. Tsatsaronis constructed the framework of equilibrium expression in exergy pricing and the cost of the pricing method and developed a complete exergy economic analysis evaluation methods [7]. Bai, Zheng and Wang studied the application of supply chain management based on exergy economics, they introduced the concept of environmental negative factor and established a set of general supply chain management subsystem exergy economic mathematical model [8]. Meanwhile Jiang, who used exergy economic analysis in the field of thermal analysis of SKS lead smelting method, integrated environmental considerations into the company's cost and give a comprehensive expound of lead smelting method [9].

Exergy Economic Analysis

With an energy perspective to examine enterprises and economic development and it is easy to find out that the power source of social development and production activities not only from the capital and labor, but also from the environmental resources. From a macro point of view, it could be described the efficiency of entire production activities and life activities level by quality, quantity and structure of resources. From the micro point of view, the enterprise production efficiency can be described by efficiency of using exergy of the total exergy input into the system. This evaluation method can be unified consideration of energy efficiency, conversion, transmission and utilization, can be clearly demonstrated the relationship between the efficiency and the use of enterprise between the various elements. So that this study will evaluate the internal control implementation of C company from the energy used efficiency, efficiency of labor and capital utilization efficiency to verify the application of exergy analysis in evaluating the efficiency of internal control.

Calculation on Exergy of Energy. Energy is an important factor of production, it drives production directly so that the utilization ratio of energy could directly reflect the efficiency of enterprise internal control. To analyze company's overall energy use efficiency, we introduce a weighted average of the overall exergy efficiency, calculate as the formula Eq.1.

$$\Psi_{\text{overall}} = \sum_{m,n} \frac{\eta_m}{\gamma_n} * Fr_{mn} = \sum_{m,n} \Psi_{mn} * Fr_{mn} \quad (1)$$

Ψ_{overall} represents weighted average overall exergy efficiency, η_m represents the energy efficiency of the m-th production projects. γ_n for n-th exergy coefficient of energy Fr_{mn} represents n kind of energy of the m-th the proportion of the total energy production projects.

Calculation on Exergy of Unit of Funds. Capital as one of the factors of production is used to purchase the corresponding production capacity and maintain businesses running. Therefore, the utilization rate of funds is one of the important indicators to measure the ability of business and higher unit capital exergy value represents the more flexible use ability and higher use efficiency of funds. Unit exergy cost of fund can be calculated by the formula Eq.2.

$$ue_c = \frac{\sum UE_i}{\sum C_{ue,i}} \quad (2)$$

$\sum UE_i$ represents total energy input into the system, $\sum C_{ue,i}$ represents the total amount of fund to purchase corresponding energy. For calculation of the resources in the industrial system, general with input energy production system on the basis of the exergy value calculation.

Calculation on Exergy of Labor. As one of the four factors of production, the cost of labor is the production and operation activities of labor inputs in the production process has the feature of commodity and could be measured by money. Therefore, labor efficiency can also be calculated based on exergy efficiency performance and transformed into fund to evaluate. This study mainly computes the labor efficiency of the production sector, the efficiency of management personnel use proportion assigned to the production process by Delphi method, the calculation as shown in formula Eq.3.

$$UE_L = ue_c C_L \quad (3)$$

UE_L represents exergy value into the labor in the process of production, C_L represents unit wage for labor.

Exergy Economic Analysis on A Certain Company

Introduction to C Company Internal Control. C company is one of the developing, producing and marketing cable companies and is identified as the national high-tech enterprise. However, with the intensification of competition in the cable industry, with the accelerate market change and emergence of internal waste, in order to break the previous mode of production, establish a new production process to reduce costs and increase efficiency, realize fast response to the market and coordination between the various departments by using information technology, C company implemented ERP system mainly in the sales management department, production management department, the five plants, financial management, technology management, general management, quality inspection departments and other departments to implement in 2009.

Calculation on Exergy of Energy. C company mainly use the types of energy are coal and electric power, coal is mainly used for smelting while electricity primarily for the operation of production equipment and office staff. Therefore, the change of the enterprise production efficiency in the production process can be calculated by productivity of the enterprise and the energy use in C company is calculated as shown in Table 1.

Table 1 Energy utilization of C company

	2009	2010	2011	2012	2013
Coal (t)	514	482	476	527	536
Electricity (MKh)	18500	16480	17620	15000	17040
Total Energy Consumption (Standard Coal)	2640.8	2369.96	2505.51	2219.94	2477.08

Because the enterprise operation efficiency can be calculated and evaluated by some indicators such as the working time of equipment, maintenance time, the yield of product and production cycle [10]. Therefore, analyze C company equipment utilization, measure equipment mechanical efficiency before and after the informationization implemented and calculate the exergy efficiency of each year as shown in Table 2.

Table 2 Energy consumption of C company

Energy Type			Coal	Electricity	Total Energy	η	$\psi/\%$
2009	Energy Consumption	$10^8 J$	135.4	665.2	800.6	20%	19.73
		Proportion%	0.169	0.831			
	Exergy Consumption	$10^8 J$	146.2	665.2	811.5		
		Proportion%	0.180	0.820			
2010	Energy Consumption	$10^8 J$	127.0	592.6	719.6	23%	22.86
		Proportion%	0.176	0.824			
	Exergy Consumption	$10^8 J$	137.1	592.6	729.8		
		Proportion%	0.188	0.812			
2011	Energy Consumption	$10^8 J$	125.4	633.6	759.0	25%	24.67
		Proportion%	0.165	0.835			
	Exergy Consumption	$10^8 J$	135.4	633.6	769.0		
		Proportion%	0.176	0.824			
2012	Energy Consumption	$10^8 J$	138.8	539.4	678.2	25%	24.60
		Proportion%	0.205	0.795			
	Exergy Consumption	$10^8 J$	149.9	539.4	689.3		
		Proportion%	0.218	0.782			
2013	Energy Consumption	$10^8 J$	141.2	612.8	754.0	26%	24.63
		Proportion%	0.187	0.813			
	Exergy Consumption	$10^8 J$	152.5	612.8	765.3		
		Proportion%	0.199	0.801			

Therefore, overall exergy efficiency can be calculated in a particular year as shown in formula Eq.4.

$$\bar{\Psi}_1 = (\psi_c f_{c,t} + \psi_d f_{d,t}) + (\psi_c f'_{c,t} + \psi_d f'_{d,t}) \tag{4}$$

$\bar{\Psi}_1$ for the tth year overall exergy efficiency, ψ_i for the ith ($i = c, d, e$) types of fuel exergy efficiency, $f_{i,t}$ for the ith fuel share the total fuel ratio in main production activities, $f'_{i,t}$ for the ith fuel share the total fuel ratio in By-production activities, thus calculate the overall exergy efficiency change after implementation of information technology based on the data from 2009-2013 and shown in Figure 1. It is clear that the energy use of exergy efficiency as a steady growth from 2009 to 2011 and the exergy efficiency is leveling off from 2011 to 2013 of C company. Also, it can be seen that energy using the exergy efficiency have a leap from 2009 to 2010 and then a few years is leveling off.

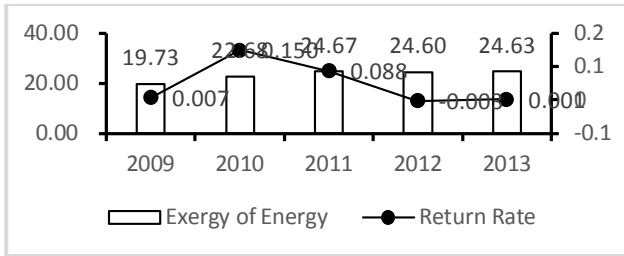


Figure 1. Finite Exergy of energy utilization efficiency

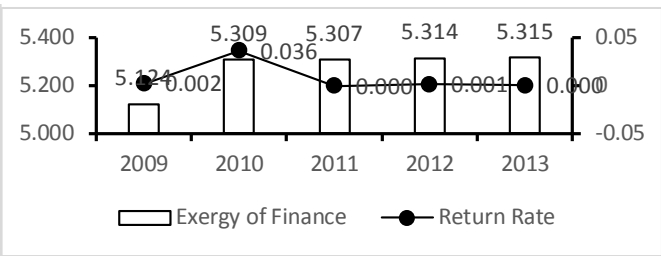


Figure 2. Finite Exergy of unit funds utilization efficiency

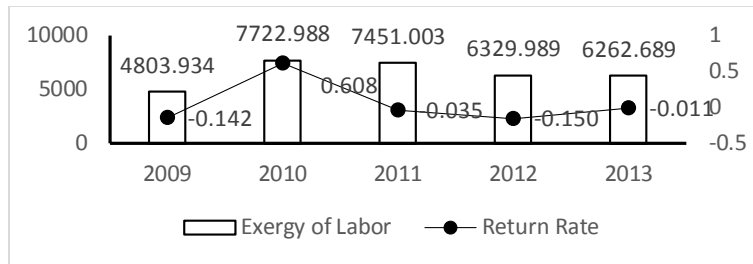


Figure 3. Finite Exergy of labor utilization efficiency

Exergy Economic Analysis on Unit Funds. Because the C company belongs to the capital-intensive enterprise and unit labor share higher amounts of funds, therefore the capital efficiency will greatly affect business performance. For example, in 2009, the years of unit exergy value funds could have calculated as Eq.5.

$$ue_c = \frac{\sum UE_i}{\sum C_{ue,i}} = \frac{13713.6+59262.1}{424000+13068} = 5.124 \text{ (MJ/¥)} \tag{5}$$

On this basis, unit exergy of funds can be calculated in 2009-2013 were 5.124 MJ/¥ (¥ represents the currency of China), 5.309 MJ/¥, 5.307 MJ/¥, 5.314 MJ/¥ and 5.315 MJ/¥ (Unit fund have can drive exergy value of manufacturing and management to a higher level) as shown in Figure 2. It is clear that there was a mutation in 2009 to 2010 and units of fund exergy 5.124 MJ/¥ to 5.309 MJ/¥, an increase of 3.6% and it is stable in rest years with a value of 5.310.

Exergy Economic Analysis on Labor. Taking the year of 2013 as an example, the total number of employees was 532 and average salary is 48962 yuan a year, corporate administrative expenses was 51516244 yuan, accounting for 10% of the cost of management wages. Thus, the exergy of labor in 2013 could be calculated as the Eq.6.

$$UE_L = ue_c C_L = 5.124 * \frac{48962 * 532}{23442.9} * (1 + 0.1) = 6262.69 \text{ (MJ)} \tag{6}$$

Thus, the exergy of labor was 4804MJ, 7723 MJ, 7451 MJ, 6330 MJ, 6263 MJ (The exergy value that every labor force costs in product per unit) from 2009 to 2013 and shown as Figure 3 and the figure shows that there also have jumping mutation in C company from 2009-2010, an increase of

60.8%. The exergy has decreased from 2010-2013 but the overall exergy value still greater than 2009 labor greatly. The reason is that the internal control will be attenuation with the time goes.

Conclusion

The exergy economic analysis, which is based on second law of thermodynamics, analyzes internal control from aspects of rate capital utilization, energy utilization and labor force utilization. It clarifies the results after the informationization of a company in three dimensions. Therefore, using the exergy economic analysis method can eliminate the influence from external factors and lead to financial indicators change and evaluate the efficiency of internal control directly from the utilization efficiency of enterprise production factors. This method has fundamentally explained the function and effectiveness of internal control and pointed out the direction of the internal control at the same time.

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