Economic evaluation of the Health, Safety and Environment (HSE) management system

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Abstract

Today, the growth of high technology industry causes some problems like air pollution, job side effects and occupational diseases which force us to implement an HSE-MS management system in different projects. This study will measure the profitability of investment in HSE-MS system using the internal rate of return (IRR) method. In this cross-sectional study, the values of the project cash flow stream in terms of different time periods were predicted. So, the calculation of these values as crisp numbers was so risky and the accuracy of final results will be ambiguous. Hence, this study has defined the values of cash flow streams as fuzzy numbers and then calculated the profitability of the HSE-MS system implementation project using the IRR measure under fuzzy environment.

The mean value of IRR was equal to 22% by using the FIRR (Fuzzy Internal Rate of Return). Also considering the point that the minimum value of IRR based on the FIRR was 14% and 18% respectively and the fact that these values are greater than the market rate (7%), the HSE-MS system implementation will be an economic and advisable project. The economic evaluation of the HSE-MS system was performed using the greater possibility index. Also, a power plant in Tehran city was investigated as a case study. Based on the obtained results, the HSE-MS system implementation was strictly advisable because of its benefits.

Keywords: Economic Evaluation, Health Safety and Environment Management System, Fuzzy Internal Rate of Return.

Introduction

In developing and developed countries occupational accidents are one of the major problems, The most important parts of these costs are human costs. Deaths caused by occupational accidents result in the loss of life, years of work and related costs.[1,2] Every year, millions of occupational accidents occur worldwide some of the accidents are fatal and others lead to temporary and permanent inability.[3]

Human contemporary history has recorded several disasters with multi-billion dollar financial losses and human casualties including the explosion of the Shuttle Challenger (1986), Nuclear reactor explosion at Chernobyl (1986), Accident in Mexico (1985), Bhopal plant accident in India (1984).[4]

These accidents have brought great losses for the community, organization and workers and now the worst consequence of occupational accidents is the premature mortality of labor force.[1,5-7]

In the US, occupational accidents of construction industry result in the death of about 17.29 workers out of 100,000 between 1980 to 1992.[8] Work-related injuries are the biggest health problem worldwide and about 14 deaths per 100,000 are due to occupational accidents. Occupational accidents cause socio-economic losses such as inability, reduction of working time and the increase in health care.[9-11]

Bahrampur et al[12] studied on the building workers of Yazd city and showed that if this trend in the accidents of Yazd city continues after several years the amount of these accidents will be increased dramatically which their major cause will be the fall from height.

The HSE-MS is a regular, systematic and explicit approach accomplished with the comprehensive processes with the goal of planning, documentation and changing the methods in order to manage the detrimental factors, safe the threats and risk analysis. Like the other management systems, the HSE-MS system is developed in order to obtain a healthy working environment with the minimum amount of job-related incidents and dangers.[14,15] A notable point is that the implementation of HSE-MS management system requires spending the money and time. However, some project managers or decision makers hesitate to implement this system or implement it incompletely in order to save the money.

Feng[17] showed that safety investment in the construction industry will increase safety culture and behavior. Vatani et al[13] study indicates that before and after the establishment of HSE-MS, the maximum calculated cost was related to the production disturbance cost (before: $568,000; after $80,500) and the lowest cost was related to transfer costs (before: $15,000; after: $3,000) and other costs (before: $98,000; after: $28,500). Statistical analyses indicate that there is a significant difference (P = 0.007) between the direct and indirect costs of accidents for before and after the establishment of HSE-MS. In other words, the direct and indirect costs had multiple, significant differences. The present study indicates that the indirect cost is four times greater than the direct costs.[2]

Also, study of Teo and Feng[16] showed that investment in safety management reduces accidents and reduce the costs imposed on the industry and due to increased employee satisfaction, increases the quality of life workers.[17-21] Unlike many studies on the costs of accidents and investment on HSE-MS system, still there is no clear and scientific method to calculate the cost of accidents or the ones that are available have some blind spots, the ultimate aim of the present study is to provide a new structure in the economic evaluation of the HSE-MS management system implementation In order to reduce accidents, internal rate of return method is used under fuzzy environment.

Material and Methods

This paper sought to evaluate the profitability of HSE-MS system implementation project by defining the cash flow streams values as fuzzy numbers using the IRR method under fuzzy environment.

In order to find economic evaluation of the cash flow resulted by an HSE-MS system implementation, the following steps are suggested:

1. Calculate the accident costs based on fuzzy values before and after the HSE-MS system implementation. It is worthy to be noted that this step can be used for experts' opinions and the historical data and existed information of similar projects. Actually in this stage, first, the cash flow stream of cost arising from accidents is estimated before the HSE-MS system implementation. Then the cash flow stream value of Costs arising from accidents is estimated after the HSE-MS system implementation.

2. Calculate the income value of HSE-MS system implementation by differing the cash flow stream values of costs arising from accidents before and after the HSE-MS system implementation.

3. Estimate the amount of investment required to implement the HSE-MS system.

4. Form the final cash flow stream obtained from the implementation of HSE-MS system, sum up the income and investment cash flow streams values.

5. Calculate the profitability of the final cash flow obtained from HSE-MS system implementation using the strict exceedance possibility method.

Results

Case study: The case study is a combined cycle power plant in Tehran city (8 units of 250 MW) that corresponds to a 24-month period (during 2016 to 2017) from Construction Phase to Operation Phase. In this study, 18-month construction period and 6 months of the electricity generation are examined. It is estimated that in the stages of construction and operation of this plant, 420 workers will be working in different units.

The fuzzy cash flow stream values of costs arising from accidents before and after HSE-MS system implementation are estimated. In this stage, the required dollar amount of the investment for the HSE-MS system implementation is demonstrated as a cash flow stream. After that, the cash flow stream values of income obtained from HSE-MS system implementation and the final cash flow stream should be calculated.

The profitability of HSE-MS system implementation project should be computed using the fuzzy IRR method. To this end, first we should transform the fuzzy values of the final cash flow stream into distinct intervals using different α-cuts. Afterward, based on different α-cuts, the IRR values of the obtained cash flow streams from the combination of the lower and upper bounds should be calculated. Table 1 shows the intervals obtained for the IRR value.

Finally, the fuzzy internal rate of return is resulted by linking the intervals to each other. If the FIRR is approximated as a triangular fuzzy number, then the FIRR can be equal to 14.33%, 22.75%, 29.08% with the average value of 22.23%.

In order to evaluate the profitability of the cash flow stream, the strict exceedance possibility method has been used and assuming that the market rate is equal to 3%, 5%, 7%. Therefore, the FIRR approximated value for implementing the HSE-MS management system is equal to 14.33%, 22.75% and 29.08%. We calculate the degree to which the approximated FIRR is bigger than the market rate.

Since the lower bound of FIRR (14.33%) is greater than the upper bound of market rate (7%), therefore it can be concluded that this cash flow stream is worth undertaking in possibility degree 1 (100%).

According to the above information, the HSE-MS system implementation project is worth undertaking using FIRR emphasizing the need to implement it from an economic viewpoint. In other words, the mean value obtained for IRR measure according to both methods is almost equal to 22% which is greater than the mean value market rate of 5%. So, this project is desirable and strictly recommendable.

Discussion

Today, industries high developments and increasing the amount of incident related costs in different projects force the companies to implement an HSE-MS system. However, some managers are hesitant to apply this system completely because of different reasons.

This paper develops a new method in order to show that this system not only is not a costly project but also increases the project profitability by decreasing the incident related costs. Actually, the HSE-MS system implementation is an economical project.

Table 1
The obtained intervals for IRR value under different α-cuts

$\alpha = 0$	IRR_0 = (%14.33, %29.08)	$\alpha = 0.6$	$IRR_{0.6}$ = ((%19.57, %25.30
$\alpha = 0.2$	($IRR_{0.2}$ = (%16.17, %27.82	$\alpha = 0.8$	($IRR_{0.8}$ = (%21.17, %24.03
$\alpha = 0.4$	($IRR_{0.4}$ = (%17.91, %26.57	$\alpha = 1$	(IRR_1 = (%22.75, %22.75

The proposed method in this study first develops a model for calculation of incident related costs, before and after the incident related costs being occurred. The difference between these two financial processes shows the revenue of the HSE-MS system implementation. Then the ultimate financial process is formed by integrating two revenues and required investment for the HSE-MS implementation system, financial processes. In order to evaluate the economic assessment of the financial process for an HSE-MS system implementation, the IRR method which is one of the attractive methods is used.

Using this method, by defining the financial process values based on different time periods and considering the time value of money, the attractiveness of financial processes is evaluated. Because of existing uncertainty in predicting financial process values and also in order to decrease the ultimate risk of the solution, all values of financial process flows are defined as fuzzy numbers. It is worthy to be noted that whenever the financial process values are defined like this, the IRR value is also obtained as a fuzzy number.

In this study, a method has been proposed based on the existing techniques in fuzzy sets theories by which the FIRR value can be computed by a higher reliability level. The economic evaluation of the HSE-MS system is performed using the greater possibility index. Also, a power plant is investigated as a case study. Based on the obtained results, the HSE-MS system implementation is strictly advisable because of its benefits. The mean value of IRR was equal to 22% by using the FIRR. The minimum value of IRR based on the FIRR was 14% and 18% respectively and these values are greater than the market rate (7%), the HSE-MS system implementation is an economic and advisable project.

Conclusion

Economic evaluation of the effectiveness of HSE-MS system can be justified for the manager to invest in these systems (HSE-MS system). It is one of the best methods of economic evaluation of the internal rate of return method.

The internal rate of return method to assess the economic impact analysis HSE-MS system makes investments to reduce the cost of occupational disease, occupational hazards and cost accident.

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