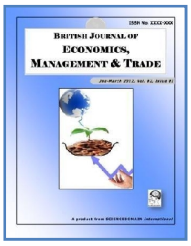

British Journal of Economics, Management & Trade
2(3): 212-224, 2012

SCIENCEDOMAIN *international*
www.sciencedomain.org

The Effects of Risk Assessment (Hirarc) on Organisational Performance in Selected Construction Companies in Nigeria

M. O. Agwu[1*]

[1]Department of Business Administration, Niger Delta University, Wilberforce Island, Bayelsa State, Nigeria.

Research Article

Received 16th March 2012
Accepted 3rd July 2012
Published 6th August 2012

ABSTRACT

The paper focuses on the effects of risk assessment (Hirarc) on organisational performance in selected construction companies in Nigeria. Risk assessment (Hirarc) is a structured approach for identifying, evaluating and controlling hazards in the workplace with a view to achieving better organisational performance of no harm/damage to people, assets, environment and reputation. The objective of this research is to ascertain the extent of compliance and influence on organisational performance (reduced accident/ incident rate, improved safety practices, enhanced productivity and increased profitability) of risk assessment (Hirarc) in the six selected construction companies in Nigeria. Thus, the research question addressed the extent of compliance and influence of risk assessment (Hirarc) on organisational performance in the six selected construction companies. This research is based on the "Domino Theory" of accident prevention as propounded by Heinrich, Petersen and Nester (1980). It assumes that compliance with risk assessment (Hirarc) will eliminate the third piece of domino (unsafe acts or physical hazard factor) from the series and prevent accidents/ incidents from happening thus resulting in better organisational performance (reduced accident/ incident rate, improved safety practices, enhanced productivity and increased profitability). The research concludes that compliance with risk assessment (Hirarc) at the organisational level in construction companies in Nigeria will improve organisational performance(reduced accident/ incident rate, improved safety practices, enhanced productivity and increased profitability). It therefore, recommends among others: visible top management/employees commitment to risk assessment (Hirarc), competitive safety intelligence, high-level safety knowledge flow management and co-operative safety resourcing as a means of sustaining safety best practices in the Nigerian construction industry.

**Corresponding author: Email: mbaagwu38@yahoo.com;*

Keywords: Hazards; risks; controls; risk assessment (Hirarc); domino theory.

1. INTRODUCTION

The global poor safety record of the construction industry in terms of accident/incident rate makes organisational compliance with risk assessment (Hirarc) imperative especially in Nigeria where weak construction safety regulations and absence of a central safety council currently prevails. No construction project is risk free. Risk can be managed, minimized, shared, transferred or accepted but cannot be ignored (Latham, 1994). Specifically, construction is widely recognized as one of the most hazardous occupations for those who work in the industry and a significant source of accidents for members of the general public who are affected by its operations (Churched and Albania Starr, 1996). Accidents and ill health can ruin lives and affect the organisation through loss of output, damage of equipment/machinery, increased staff turnover, reduced workers morale, damage of organisational reputation, increased insurance costs and payment of medical bills/compensation/fines.

Construction activities involve numerous stakeholders, long production hours and an open production system that entails significant interaction between internal and external environments (BS 6079-4:2006). Such organisational and technological complexity generates enormous risks (Zou et al., 2007). Since construction activities are prone to a lot of risks, it becomes imperative that these risks need to be assessed and managed through a structured risk assessment (Hirarc) process. Risk reflects both the likelihood and severity that harm will occur from an identified hazard (Shell, 2005).

Risk assessment (Hirarc) is a structured approach for identifying, evaluating and controlling hazards in the workplace with a view to achieving better organisational performance of no harm/damage to people, assets, environment and reputation. It may also be defined as a process of determining the probability and consequences of an identified hazardous event and its risks to workers (Colling David, 1998). It entails evaluating the risks associated with the identified hazards, so that appropriate controls may be taken based on the probability and severity of the potential hazard.

Construction companies in Nigeria are legally required to assess and control the risks associated with their activities. In construction sites, some hazards are readily identifiable (chemical and physical hazards), while others (ergonomical, biological and psychosocial hazards) may require specialized techniques (risk assessment (Hirarc), Job hazard analysis (JHA), what if analysis, fault tree techniques, hazard and operability study and accident investigation) to identify. The effects of each of these techniques on organisational performance cannot be overemphasized. It is against this background that it becomes pertinent to embark on a research that unravels the effects of risk assessment (Hirarc) on organizational performance in selected construction companies in Nigeria.

1.1 Objectives of the Research

The objectives of this research are as follows:

1. To ascertain the extent the six selected construction companies complies with risk assessment (Hirarc) in their activities at the organisational level.

2. To ascertain the extent of influence of risk assessment (Hirarc) on organisational performance (reduced accident/incident rate, improved safety practices, enhanced productivity and increased profitability) in the six selected construction companies.

1.2 Research Questions

From the above research objectives, the following research questions are formulated:

1. To what extent does the six selected construction companies complies with risk assessment (Hirarc) in their activities at the organisational level?
2. To what extent does risk assessment (Hirarc) influence organisational performance (reduced accident/incident rate, improved safety practices, enhanced productivity and increased profitability) in the six selected construction companies?

1.3 Research Hypothesis

In view of the above research questions, this null hypothesis was formulated:
H_o: Better organizational performance (reduced accident/incident rate, improved safety practices, enhanced productivity and increased profitability) is not dependent on risk assessment (Hirarc) compliance in the six selected construction companies.
H_1: Better organisational performance (reduced accident/ incident rate, improved safety practices, enhanced productivity and increased profitability) is dependent on risk assessment (Hirarc) compliance in the six selected construction companies.

2. BACKGROUND FOR THE PAPER

2.1 Literature Review

During the 1990's construction risk assessment and modeling gained momentum and became a 'hot topic' for research. Researchers were primarily building upon previous works, centered on two main schools of thought: Probability Theory and Fuzzy Sets Theory (FST), though, they were open to other tools, techniques and approaches. For example, Hull (1990) introduced different models, based on Monte Carlo simulation (MSC) and PERT, to assess potential risk from cost and duration points of view, while Yeo (1990) presents a 'contingency engineering' method, using both range estimate method and the PERT technique, to assess cost, risk and estimate contingency.

Mustafa and Al-Bahar (1991), adopted the Analytic Hierarchy Process (AHP) to assess construction project risk. AHP applied the concept of value and weight to assess risk probability and impact. Likewise, Dey et al. (1994), presented a risk assessment methodology, based on AHP, which combined objective and subjective assessments with Probability-Impact (P-I). Riggs et al. (1994), proposed an approach for quantifying and integrating technical, cost, and schedule risks as utility functions. AHP was used to assign probabilities to a decision tree: the option with the maximum utility was chosen. Similarly, Diekmann (1992) discussed AHP from a theoretical and practical perspective, applicability and shortcomings based on probability theory. He concluded that the methods utilized at that time were either too simplistic or too complicated to be used by practitioners.

Paek et al. (1993) proposed a risk-pricing algorithm, using FST, to assist contractors when determining the bid price of a construction project. Wirba et al. (1996) also presented an FST-based risk management approach, which identifies risks, checks for dependence

amongst them and assesses risk likelihood of occurrence by using linguistic variables. While this model is widely cited, concern has been raised over the use of interdependence coefficients for dealing with risk interdependencies. Coefficients were computed by using the fuzzy weighted mean method, which is a point of weakness in FST, as it only calculates the weighted average.

A stochastic model, which combines the randomness of the cost and the duration of a project activity, was developed by Tavares et al. (1998). Project risk was modeled as the probability of not meeting project objectives, i.e. duration and cost; however, no other objectives were considered. Mulholland and Christian (1999) used the PERT technique to develop a distribution of project duration. The variance of the duration distribution of a project was used to measure scheduled risk: the larger the variance, the greater the risk associated with project duration.

This research views risk assessment from the perspective of identification and removal of hazards (unsafe acts/conditions) that could lead to accident in construction sites based on the accident preventive model of Heinrich et al., 1980 in the "Domino Theory" of accident prevention.

2.2 Legal Framework

Section 19 of the Safety, Health and Welfare at Work Act, 2005 requires that employers of labour and those who control workplaces to any extent should:

- Identify the hazards in the workplaces under their control
- Assess the risks presented by these hazards.

In this context, a hazard is anything with potential to cause harm (hydrocarbon under pressure, noise, sharp edges of machines, improper work methods etc.), while risk measurement depends on:

- The likelihood (probability) of the hazard being released or the undesired event/harm occurring in the workplace.
- The potential severity/consequences of the harm (i.e. degree of injury or ill health following an accident).
- The number of people who might be exposed to the hazard.

Employers must write down these workplace risks and what to do about them. This is known as a risk assessment. Assessing risk means you must examine carefully what, in the workplace, could cause harm to your employees, other employees and other people, including customers, visitors and members of the public. This allows you to weigh up whether you have taken enough (suitable and sufficient) precautions or whether you should do more to prevent harm.

Employers are required to implement any improvements considered necessary by the risk assessment process. The aim is to make sure that, no one gets hurt or becomes ill. It is important to remember that, in identifying hazards and assessing risks, employers should only consider those which are generated by work activities. There is no need to consider every minor hazard or risk which we accept as part of our lives.

2.3 Theoretical Framework

This paper is based on the theory of industrial accident prevention model as propounded by Heinrich, Petersen and Nester, 1980 in the "Domino Theory" of accident prevention. The domino theory states that the occurrence of injuries or fatality is as a result of the fall of a chronological sequence of five dependent factors arranged in alignment like a series of dominoes as illustrated in Fig. 1 below. Each domino represents each factor. The fall in one domino eventually will precipitate the fall of the entire row. If the series of this row of dominoes is interrupted by the elimination of one of the several factors that constitute and causes it, injury or accident will not occur.

The compliance of construction companies with risk assessment (Hirarc) eliminates the third piece of domino (unsafe acts or physical hazard factor) from the series, thus preventing accident from happening. The mechanism of preventing accidents affiliated with domino theory is illustrated in Fig. 2 below.

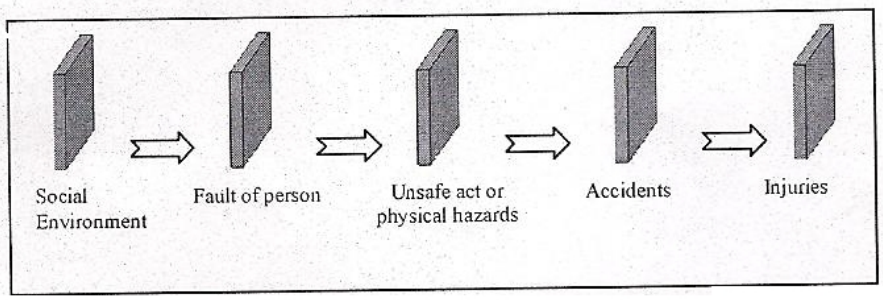

figure 1. Domino Theory (Adapted from Heinrich, H.W, Petersen, D and Nester, R (1980). Industrail Accident Prevention: A safety Management Approach. New York:McGraw-Hill

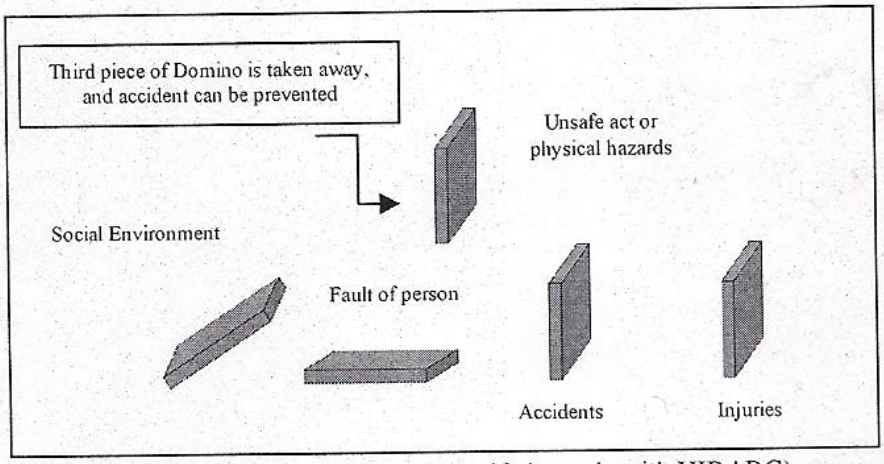

Figure 2. Domino Theory (Identify hazards with HIRARC)

Inadequate risk control and management causes accidents and signifies management failure (Haslam et al., 2005). Studies in Hong Kong and other parts of the world have shown that implementation of hazard identification and risk control has reduced accidents drastically since 1986 (Tam and Chan, 1999). Optimistically**,** by giving adequate attention to

the proper implementation of a safety management system, accidents at construction sites may be avoided or minimized with the doctrine of Hirarc (NIOSH, 2005).

3. METHODOLOGY

3.1 Risk Assessment Methodology

Although risk assessment in the construction industry is controversial, however, it is frequently considered to be the most useful part of the risk management process (Baloi and Price, 2003).

Despite the difficulties in obtaining objective probabilities in the construction industry, the focus has been on quantitative risk assessment (Flanagan and Norman, 1993). Quantitative risk assessment entails the calculation of the two components of risk (R): the magnitude of the potential loss (L) and the probability (P*)* that the loss will occur. The absence of quantitative risk assessment data negates the use of a probabilistic approach in the assessment of construction risks hence project managers are obliged to rely on the elicitation of subjective probabilities (Winch, 2003). Thus, individual knowledge, experience, intuitive judgment and rules of thumb should be structured to facilitate the construction risk assessment process (Dikmen et al., 2007).

The process of risk assessment in construction activities involves the following five steps: Step 1 identifies the hazards, Step 2 decides who might be harmed and how, Step 3 evaluate the risks and decides on precautions, Step 4 record the findings and implement them and Step 5 review the assessment and update if necessary (HSE,2011).

3.1.1 Step 1 identify the hazards

This is the process of examining each work area and work task for the purpose of identifying all the hazards which are “inherent in the job”. It requires that: (i) past incidents/accidents should be examined to see what happened and whether the incident/accident could happen again. (ii) Employees should be consulted to find out what they consider as safety issues, e.g. how could an employee be exposed to this hazard? (iii) Work areas or work sites should be examined (safety audit) to find out the current situation. (iv) Information about equipment (e.g. plant, operating instructions) and material safety data sheets should be reviewed to see what is said about safety precautions.

All hazards that have been identified should be dealt with in order of priority in one or more of the following ways:

(i) **Eliminate the hazard** - remove it from the workplace.
(ii) **Substitute the hazard** - substitute a substance, method or material to reduce the risk or the hazard.
(iii) **Isolate or enclose the hazard** - separate the hazard from the workplace, e.g.:
  (a) Chemical store room, or laboratory kept locked except to an authorized person.
  (b) Lock out procedures on faulty equipment.
  (c) Appropriate guarding for machinery.

(iv) **Use engineering solutions** – modify existing machinery or plant or purchase different machinery or plant.
(v) **Administrative Procedures** - develop work methods to reduce the conditions of risk, e.g.: (a) Written Safe Operating Procedures, (b) Job rotation to restrict hours worked on difficult jobs, (c) Staff trained in the correct operating procedures.
(vi) **Use Personal Protective Equipment (PPE) and training in its use** - this should only be used as a last resort to deal with the hazard, where the hazard cannot be removed or reduced by any other means, e.g.: (a) Handling of chemicals – gloves, safety glasses, aprons, (b) Protecting eyes from flying particles, (c) Protecting feet – safety boots.
(vii) **Finding solutions to hazards may involve:** (a) Assessment of the hazard by other stakeholders, (b) Giving consideration to make procedural changes both in-house and/or with other stakeholders, (c) Making changes to work practice or behaviour.

3.1.2 Step 2 decide who might be harmed and how

For each hazard you need to be clear about who might be harmed; it will help you identify the best way of managing the risk. If you share your workplace, you will need to think about how your work affects others present, as well as how their work affects your staff – talk to them; and ask your staff if they can think of anyone you may have missed.

3.1.3 Step 3 evaluate the risks and decide on precautions

The process of assessing the risk is undertaken by reviewing any available information about the hazard (e.g. a law, regulation, industry code of practice or guidance material about the hazard) and by using your personal work experience on what sort of accident or illness the hazard could create and how likely this would be to happen. When determining how likely it is that a person could be exposed to a hazard or hazardous event, consideration needs to be given to these “exposure factors”: (i) Whether there are any other risk factors that increase the likelihood of exposure? (ii) How often is the person exposed (frequency)? (iii) For how long is the person exposed (duration)? (iv) How many people are exposed? (v) The likely dose to which the person is exposed? (vi) Any legislative or recommended exposure levels required by statutory authorities.

3.1.4 Step 4 record your findings and implement them

Writing down the results of your risk assessment and sharing them with your staff is very important. If you have fewer than five employees you do not have to write anything down, though it is useful so that you can review it at a later date if, for example, something changes. When writing down your results, keep it simple. Make a plan of action to deal with the most important things first. Remember, to prioritize and tackle the most important things first. As you complete each action, tick it off your plan.

3.1.5 Step 5 review your risk assessment and update if necessary

Few workplaces stay the same. Sooner or later, you will bring in new equipment, substances and procedures that could lead to new hazards. It makes sense, therefore, to review what you are doing on an ongoing basis. Check your risk assessment and, where necessary, amend it. If possible, it is best to think about the risk assessment when you are planning your change – that way, you leave yourself more flexibility.

Hazard identification, risk assessment and risk control (Hirarc) as a strategic planning procedure should be implemented on construction sites as an effective safety management system to control risks and reduce accidents (Loughborough University of Technology, 1994). It entails the company establishing a risk assessment team which includes workforce representatives and competent personnel within the organization. These personnel will be trained and briefed about their roles, objectives, and management's safety policy and scope of the Hirarc procedure.

Periodically, all relevant Hirarc documents will be collected and planned according to agreed methodology. During any assessment, action plans are prepared and collated for each evaluated and defined risk. The researcher believes that it is only when the above risk assessment procedure is religiously implemented by the six selected construction companies can its intended benefits be realized.

3.2 Research Methodology

The scope of the research is limited to the six most populous construction companies in Nigeria (Julius Berger Nigeria Plc, Setraco Nigeria Ltd, Fourgerolle Nigeria Ltd, Arab-Contractors Nigeria Ltd, Dantata & Sawoe Nigeria Ltd. and Costain Nigeria Ltd). It is assumed that responses obtained from workers in these selected companies would be representative of all construction workers opinion on the effects of risk assessment (Hirarc) on organisational performance. An exploratory, cross-sectional survey was used in generating the primary data required for the study. The population of study consists of 40,568 workers of three categories (3,560 supervisors, 10,028 foremen and 26,980 workmen) drawn from the six construction companies selected for the study.

A sample of 396 workers (35 supervisors, 98 foremen and 263 workmen) determined at 5% level of significance for sample error, using Taro Yamane's (1964) formula, was selected using stratified random sampling method for the purpose of questionnaire administration. The questionnaire was designed to obtain a fair representation of the opinions of the three categories of construction workers in the six selected companies using a three-point Likert type scale. The questionnaire responses of the sample respondents were presented using tables, analyzed and interpreted using simple percentages. A total of 396 copies of the questionnaire were administered, out of which 2 were cancelled while 4 were not returned and 390 (98%) were used for analysis.

4. RESULTS AND DISCUSSION

4.1 Some Results

Table 1 indicates that a total of 331 i.e. 85% of the workers across the three categories, are of the opinion that their company to a large extent complies with risk assessment (Hirarc) in their activities, 43 i.e. 11% of the workers are of the view that their company to a mild extent complies risk assessment (Hirarc) in their activities while16 workers i.e. 4% expressed a poor extent view of their companies compliance with risk assessment (Hirarc). We therefore conclude that there is evidence of a large extent compliance with risk assessment (Hirarc) in the activities of the six selected construction companies as buttressed by the 85% large extent response of the sample respondents.

Table 1. Response pattern on the extent of compliance with risk assessment (Hirarc) in the six selected construction companies

Category of Respondents/Workers	Responses Provided			
	Large extent	Mild extent	Poor extent	Total
Supervisors	25	8	2	35
Foremen	85	10	3	98
Workmen	221	25	11	257
Total	331	43	16	390

Source: Field Survey, 2011.

Table 2, indicates that a total of 345 i.e. 88% of the workers across the three categories are of the view that their company's compliance with risk assessment (Hirarc) in their activities, to a large extent influences better organisational performance (reduced accident/ incident rate, improved safety practices, enhanced productivity and increased profitability), 34 i.e. 9% of the workers are of the view that their company's compliance with risk assessment (Hirarc) in their activities, to a mild extent influences better organisational performance while 11 workers i.e. 3% expressed a poor extent view. We therefore conclude that there is evidence that compliance with risk assessment (Hirarc)in the activities of the six selected construction companies to a large extent influences better organisational performance as buttressed by the 88% large extent response of the sample respondents.

Table 2. Response pattern on the extent risk assessment (Hirarc) compliance influences better organisational performance (reduced accident/ incident rate, improved safety practices, enhanced productivity and increased profitability) in the six selected construction companies

Category of Respondents/Workers	Responses Provided			
	Very large extent	Mild extent	Poor extent	Total
Supervisors	30	3	2	35
Foremen	90	6	2	98
Workmen	225	25	7	257
Total	345	34	11	390

Source: Field Survey, 2011.

Table 3, shows that a total of 325 i.e.83.33 % of the workers across the three categories were of the view that better organisational performance depends to a large extent on their companies compliance with risk assessment (Hirarc), 45 i.e. 11.54% of the workers expressed a mild extent view while 20 i.e. 5.13% of the workers expressed a poor extent view. We therefore conclude that there is evidence that better organisational performance depends on compliance with risk assessment (Hirarc) as buttressed by the 83.33% large extent response of the sample respondents.

Table 3. Responses on the extent better organisational performance (reduced accident/ incident rate, improved safety practices, enhanced productivity and increased profitability) depends on risk assessment (Hirarc) compliance in the six selected construction companies

Category of Respondents/Workers	Responses Provided			
	Large extent	Mild extent	Poor extent	Total
Supervisors	20	10	5	35
Foremen	75	15	8	98
Workmen	230	20	7	257
Total	325	45	20	390

Source: Field Survey, 2011.

Table 4. Observed and expected frequencies of Table 3

Category of Respondents/Workers	Responses Provided			
	Large extent	Mild extent	Poor extent	Total
Supervisors	20 (29.17)	10 (4.04)	5(1.79)	35
Foremen	75(81.67)	15 (11.31)	8(5.03)	98
Workmen	230(214.17)	20 (29.65)	7 (13.18)	257
Total	325	45	20	390

Source: Field Survey, 2011

Table 5. Computation of Chi-square test statistic from Table 3

Fo	Fe	(Fo-Fe)	$(Fo-Fe)^2$	$(Fo-Fe)^2/Fe$
20	29.17	9.17	84.0889	2.8827
75	81.67	6.67	44.4889	0.5447
230	214.17	-15.83	250.5889	1.1700
10	4.04	5.96	35.5216	8.7925
15	11.31	3.69	13.6161	1.2039
20	29.65	-9.65	93.1225	3.1407
5	1.79	3.21	10.3041	5.7565
8	5.03	2.97	8.8209	1.7537
7	13.18	-6.18	38.1924	2.8978
				χ^2_c=28.1425

4.2 Test of Hypothesis

(i) **H_o**: Better organisational performance (reduced accident/ incident rate, improved safety practices, enhanced productivity and increased profitability) is not dependent on risk assessment (Hirarc) compliance in the six selected construction companies.

H_1: Better organisational performance (reduced accident/ incident rate, improved safety practices, enhanced productivity and increased profitability) is dependent on risk assessment (Hirarc) compliance in the six selected construction companies.

(ii) **$\alpha = 0.05$**

(iii) **Degree of Freedom (df) = (r – 1)(c-1= (3-1)(3-1)=4**

(iv) **Chi- square critical value** $\chi^2_{0.05} = 9.49$
(v) **Chi- square computed value from Table 4** = $\chi^2_1 = \sum(F_0 - Fe)^2/Fe$
(vi) **Decision Rule: Reject** H_o: **if** $\chi^2_c > \chi^2_t$ **or Accept** H_o: **if** $\chi^2_c < \chi^2_t$

Since $\chi^2_c > \chi^2_t$ i.e. 28.1425 > 9.49, we reject the null hypothesis and accept the alternative hypothesis that better organisational performance (reduced accident/ incident rate, improved safety practices, enhanced productivity and increased profitability) is dependent on risk assessment (Hirarc) compliance in the six selected construction companies.

5. CONCLUSION

This paper has tried to address the effects of risk assessment (Hirarc) compliance on organisational performance in the execution of construction activities in Nigeria, from accident prevent perspective. From the foregoing results and discussion of respondents' responses we can conclude that better organisational performance (reduced accident/ incident rate, improved safety practices, enhanced productivity and increased profitability) is dependent on risk assessment (Hirarc) compliance in the six selected construction companies.

6. RECOMMENDATIONS

Arising from the findings of this paper, it is suggested that the management of all construction companies in Nigeria should take the following measures:

- Continuous training of safety personnel and the entire workforce on the acquisition of modern risk assessment skills and knowledge.
- Continuous improvement on employees' motivation and safe work environment.
- Continuous top management/employees commitment to risk assessment (Hirarc).
- Continuous implementation of safety regulations and risk assessment procedures/techniques.
- Continuous review of corporate safety policies to accommodate changes in the construction environment and changes in risk assessment requirements.
- Continuous use of competitive intelligence, high-level knowledge flow management and co-operative resourcing as a means of obtaining information for improving and sustaining compliance with risk assessment (Hirarc) in their operations.

COMPETING INTERESTS

Author has declared that no competing interests exist.

REFERENCES

Baloi, D., Price, A.D.F. (2003). Modelling global risk factors affecting construction cost performance. International Journal of Project Management, 21, 261–9.

British Standards BS 6079-4. (2006). Project management - Part 4: Guide to project management in the construction industry. British Standards Institute.

Churcher, D.W., Alwani Starr, G.M. (1996). Incorporating construction health and safety into design process. Proceedings of the First International Conference of CIB Working Commission W99. September 4-7, 1996. Lisbon Portugal, 29-39.

Colling, David, A. (1998). Industrial safety: Management and technology. Englewood Cliffs, N.J: Prentice Hall.

Dikmen, I., Birgonul, M.T., Han, S. (2007). Using fuzzy risk assessment to rate cost overrun risk in international construction projects. International Journal of Project Management, 25, 494–505.

Flanagan, R., Norman, G. (1993). Risk management and construction, Oxford UK: Blackwell Publishing.

Dey, P., Tabucanon, M.T., Ogunlana, S. (1994). Planning for project control through risk analysis: a petroleum pipeline-laying project. International Journal of Project Management, 12(1), 23–33.

Holt, Allan, St John. (2001). Principles of construction safety. Oxford: Blackwell Science.

Heinrich, H.W., Petersen, D., Nester, R. (1980) Industrial accident prevention: A safety management approach. New York: McGraw-Hill.

Haslam, R.A., Hide, S.A., Gibb, A.G.F., Gyi, E.D., Pavitt, T., Atkinson, S. (2005). Contributing factors in construction accidents. Applied Ergonomics*,* Issue 36, Volume 4, 401-15.

Health and safety made simple HSE. (2011). www.hse.gov.uk/simple-health-safety/index.htm.

Hull, J.K. (1990). Application of risk analysis techniques in proposal assessment. International Journal of Project Management, 8(3), 152–157.

Latham, M. (1994). Constructing the team HSMO.

Loughborough University of Technology. (1994). Tackling risk assessment: A toolkit in support of the management of health and safety at work regulations. London: Lowe & Brydone Ltd.

Mulholland, B., Christian, J. (1999). Risk assessment in construction schedules. Journal of Construction Engineering and Management, 125(1), 8–15.

Mustafa, M.A., Al-Bahar, J.F. (1991). Project Risk Analytic Assessment Using the Hierarchy Process. IEEE Transaction on Engineering Management, 38(1), 46-52.

NIOSH. (2005). Training manual for safety and health officer certificateprogramme module 4: Occupational safety. Selangor.

Paek, J.H., Lee, Y.W., Ock, J.H. (1993). Pricing construction risks: Fuzzy set theory. Journal of Construction Engineering and Management, 119(4), 743-756.

Riggs, J.L., Brown, S.B., True blood, R.B. (1994). Integration of technical, cost and schedule risks in project management. Computers and Operations Research, 21(5), 521-533.

Shell, (2005). "SPDC bonny terminal OHSAS awareness course manual", September Vol.1 Port Harcourt: Dominion Publishers.

Smith, N.J., Merna, T., Jobling, P. (2006). Managing risk in construction projects 2nd edn, Oxford, UK. Blackwell Publishing.

Tam, C.M., Chan, A.P.C. (1999). Nourishing safety culture in the construction industry of Hong Kong. Proceedings of the Second International Conference of CIB Working Commission W99. March 24-27 1999. Honolulu Hawaii, 117-122.

Tavares, L.V., Ferreira, J.A.A., Coelho, S. (1998). On the optimal management of project risk. European Journal of Operational Research, 107, 451-469.

Wirba, E.N., Tah, J.H.M., Howes, R. (1996). Risk interdependencies and natural language computations. Engineering, Construction and Architectural Management, 3(4), 251-269.

Winch, G.M. (2003). Managing construction projects: an information processing approach, Oxford, UK. Blackwell Publishing.

Yamane, T. (1964). Statistics: An Introduction Analysis. 3rd. ed. New York: Harper and Row Publishers.

Yeo, K.T. (1990). Risks, classification of estimate and contingency management. Journal of Management in Engineering, 6(4), 458-470.

Zou, P., Zhang, G., Wang, J. (2007). Understanding the key risks in construction projects in China. International Journal of Project Management, 25, 601–614..